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To most persons—always excepting those who derive profit and *kudos* in the capacity of promoters—international exhibitions are rapidly becoming as stale, flat, and unprofitable as the bazaars got up for the benefit of philanthrophic institutions. The Council of the "Grand International Competition of Sciences and Industry" to be held next year in Belgium's capital, deserve, therefore, no small credit for elaborating a new and possibly a redeeming feature in these shows. They propound a number of questions in scientific technology and the industrial arts, and they offer prizes for the best solution of these problems. To what an extent this idea is being carried out will be seen from the fact that in electricity alone no fewer than 76 such "nuts to be cracked" are laid before the scientific public.

These questions are grouped under five subdivisions: *a*. The study and teaching of electrical science, instruments of measurement, scientific applications of electricity (rather vague!) such as lightning rods. *b*. Motors and dynamo-electric machines, the transport of motive power to a distance, the distribution of electric energy, and transformers. *c*. Telegraphy, telephony, wires, and cables. *d*. Arc and glow lamps. *e*. Batteries, accumulators, various industrial applications, electro-chemistry, electro-metallurgy, galvano-plastics, railway signals, &c.

Some of the questions asked under these divisions open up wide and novel fields for the inventor. Thus under section *d* we find a prize offered for the best lamp belonging to a system other than the arc and the glow. Further must be noticed the best arrangements for the illumination of mines, submarine works, &c., and for the best portable electric lamp.

Among the possible applications of electricity in industrial chemistry, we find no mention of some of the most important, such as in dyeing, tissue-printing, the synthetic manufacture of colours, perfumes, medicines, &c. Nor do we find any reference to the future part which electric science may play in agriculture and horticulture, such as the artificial formation of the compounds of nitrogen from their elements, which would be a giant's step towards the manufacture of human food, the destruction of parasitic animals, such as the phylloxera, and fungi, such as the potato blight, the coffee disease, &c.

There are two questions concerning the best systems of applying electricity to the management of firearms, large and small, and to torpedoes, but its possible services in combatting epidemics, in disinfecting sewage and other putrescent organic matters have been overlooked. Attempts have, as we are well aware, been made in these directions, but so far they have remained, for the most part, mere paper proposals, and in no case has the matter been brought to a definite decision.

We must not forget to mention that "a reward will be decreed to the most remarkable invention in electricity not included in the above questions submitted to competition." We hope that some of our readers may rank among the successful candidates for the rewards and honours offered. In any case, this competition will be valuable as keeping before the public mind the vast extent and variety of the useful purposes to which electricity is applicable. So far, it is probable that we have only tasted a sample of its first fruits.

VESTED INTERESTS IN BATH.

SOME misunderstanding has arisen at Bath between the civic authorities and Mr. H. G. Massingham, who has been introducing the electric light into that city. The Town Clerk wrote that he was instructed by the Corporate Property Committee to request Mr. Massingham to remove the poles used for some installations by the following day, whereupon the latter replied that he could not undertake to do so at so short a notice, but promised that the electric light should not be exhibited in the city after the following night, and that the poles and wires should be removed as quickly as possible. Mr. Massingham added, "I cannot but express my surprise that a body which is supposed to exist solely for the public good should adopt this means of enforcing the discontinuance of the electric light in Bath." Why Mr. Massingham should have been thus peremptorily ordered to remove his electrical apparatus is somewhat of a mystery, especially considering that only on May 12th last the same committee gave him permission to fix his poles and attachments, provided that he did no damage or made good any that he might occasion, and removed them on a date mentioned, which had not expired by four days when the letter from the Town Clerk was received. It is quite clear, however, that the dignity of the "Conscript Fathers" has been upset in some unaccountable way, and they have already shown their displeasure in true parochial fashion. Hitherto Mr. Massingham has been permitted the use of the fire-escape in order to reach his electric lamps in front of the Guildhall, but a few days since on making the usual application he was politely refused, the committee having given directions that he was no longer to enjoy its use. The Chairman of the Watch Committee (Alderman Hammond), on being appealed to, ordered that the escape should be lent to Mr. Massingham as before, but just then the Chairman of the Corporate Property Committee intervened, and the privilege was again denied, although it was subsequently allowed through the intervention of the Mayor. Such paltry behaviour on the part of the committee in question is, of course, only calculated to bring upon them well-deserved contempt. Four of the members, it should be stated, are members of the local gas company, which explains a good deal that would be otherwise inscrutable.

AS we have been able to inform our readers, several French municipal councils—those of Paris, St. Etienne and Lyons amongst the number—have ordered the abandonment of gas for lighting purposes in theatres and the adoption of the electric light. *La Liberté*, a paper published in Paris, thinks the worthy councillors, in obeying the instinct of self-preservation, have overshot the mark, or, at any rate, have not hit it as squarely as they thought they had. Its article on the subject of "Theatre Lighting," however, is carefully written and temperate in tone. The points of danger in electric lighting installations are pointed out, and for the greater part we are in accord with the statements of the writer; but we are not disposed to accept what appears to be his final deduction, namely, that an unreasonable number of minute precautions are necessary to render electric lighting absolutely safe.

HOW generous are the Americans! They delight to honour those whom they admire, and if they can do so in no other way they bestow titles upon them. "Professor Reckenzaun" sounds strangely to our unaccustomed ears, but by the dwellers in that blessed land of equality across the wide Atlantic the phrase is used in all sincerity and seriousness to denote a man who has brought them knowledge which they did not previously possess. If the title is not his by right, as right is understood in England, say they, he deserves that it should be his, and so they forthwith sit, figuratively, at the feet of Professor Reckenzaun.

IT is interesting to notice that, whilst Mr. Reckenzaun has gone to the States on matters relating to secondary batteries, his useful work in connection with motors is recognised and appreciated there. Accounts reach us of experiments under his direction in Philadelphia with an ordinary street car containing secondary batteries and an electric motor, arranged, we presume, upon Reckenzaun principles. A number of New York and Philadelphian capitalists were present, and, as the experiments were successful, we may reasonably expect to hear more from the other side respecting this mode of conducting street traffic by electrical means.

IT is to be hoped that the revised conditions under which the Society of Arts trials of motors for electric lighting have been arranged will meet with some response. We should imagine that manufacturers would not hesitate to submit their productions to the tests laid down by a society whose *bonâ fides* is beyond the breath of suspicion. As we pointed out only a fortnight since, the economical production of motive power is of vital importance to the electric lighting industry, and we sincerely trust that the society will not have to seek a second time in vain for engineers to come forward with sufficient faith in their apparatus to submit them to an impartial and thorough trial.

THE lighting of railway cars by electricity, which has been carried on in a half-hearted sort of way in this country, seems to have taken a fair hold in America. Mr. Blodgett, whose paper we publish in our present issue, deals very practically with the subject, and clearly shows that in the States, at least, it is more than probable that glow lamps will eventually supersede all other methods of lighting passenger carriages.

A MONOPOLY for 50 years! How this tempting bait must make speculative contractors' mouths water! But the municipality of Leon, though it nominally calls its offer one of 50 years' monopoly, is not without some glimmerings of sapience. It asks for tenders for lighting the streets of the town by electricity on terms which, if peculiar, are yet likely to be as favourable to itself as to the fortunate contractor. It states a price which it is willing to pay, and will give the contract to the tenderer agreeing to the lowest number of years for the monopoly. This appears to resolve the affair into a contest of daring amongst electric lighting firms.

THE members of the Paris Municipal Council appear to possess the same kind of modest generosity which is said to have characterised the members of a similar body in Auld Reekie, once on a time. The latter wished each to have a beautiful lamp erected in front of his domicile as an indication of his municipal rank, the cost to come, of course, out of the public funds. The Parisian Councillors recently resolved that each member of the corporation should be provided with a telephone out of the rates. The press, however, raised an outcry against the misappropriation of public money, and at a subsequent council meeting the resolution was rescinded after a violent debate. Perhaps the telephone company alone, of all the ratepayers of Paris outside the council, was in cordial agreement with the first resolution, and disappointed with its cancellation; for it is very certain that it had not the consolation of reflecting that the councillors would have the telephone, even if they had to pay for it themselves. Such, unfortunately, is not the heroic inclination of the mind municipal.

WE hoped to have had something to say this week respecting the primary battery of Mr. Schanschieff, but pending the conclusion of some trials which his apparatus is undergoing in the laboratory of our leading electrical expert, we are compelled to postpone any mention thereof beyond the fact that the results have surpassed the most sanguine expectations of the inventor. Mr. Schanschieff does not pretend to accomplish what are considered as impossibilities in primary battery working, and we shall, therefore, be all the more pleased to chronicle his success.

IN our Notes which appeared in the June 17th issue of the REVIEW, we referred to the brake tests undertaken by the Chicago, Burlington and Quincy Railway, and to the important part which electricity will probably play in the future in connection with train braking. A perusal of the article which we reproduce this week from an engineering contemporary, will show what has already been accomplished in this direction, the combination of the air brake with electrical actuating apparatus being, in our opinion, likely to come to the fore. The brake question is one which has occupied the public mind, even if railway directors have affected to ignore its importance, for many years past, and we live in the hope that at some future period—which, however, we are not likely to witness—the trains on all our lines will be under perfect control. The opinion of Mr. Clement Stretton on the Carpenter automatic electro-air apparatus would no doubt be considered of great value on a matter of such vital interest to the travelling public.

RECENT ADVANCES AND IMPROVEMENTS IN THE APPLICATION OF ELECTRICITY TO RAILWAY WORKING.

(*Continued from page* 4.)

INTERLOCKING SYSTEMS.

By interlocking systems is meant a means of interlocking the electric block signals with the mechanical signals which are visible to the drivers, and which, consequently, are directly responsible for controlling the movement of railway trains.

Interlocking, as thus understood, has not taken any very great hold on our railway system so far. On the London, Brighton and South Coast Railway Messrs. Saxby and Farmer established their system at some few signal posts, now sometime since, but no extension of it has taken place. On the London, Chatham and Dover line, however, greater progress has been made; Mr. Sykes's system having been very freely employed upon it. We should also mention that Mr. Sykes has been successful in establishing his system throughout the Hull and Barnsley railway, a comparatively new line. With the exception of a short section of the Midland Company's Manchester and London route between Derby and Trent, upon which a system, of which Mr. Langdon is the author, and which applies more especially to the single needle form of block, has been in use for some three years, nothing further would seem to have been done by railway companies. Although Mr. Spagnoletti, of the Great Western, is the author of a system of interlocking, it does not appear to have secured the favourable consideration of the directors of that company, for we do not hear of its employment upon the Great Western line, although it has been in use upon the Metropolitan, experimentally, for some time. It has also been employed upon the connecting section between the Metropolitan widened lines at King's Cross (Metropolitan) and the Midland.

The advantage of such a system cannot fail to be apparent when we take into consideration the fact that however perfect may be the electrical system, without a means of combining it with the mechanical signals, the one has to be worked quite independently of the other, and it thus becomes possible for mistakes to be made.

Where the electrical signals are made to control or govern the key signal of the block section, then, of course, the signalman is not in a position to operate that signal, unless the electrical signal allows him to do so. Yet, although the Board of Trade has from time to time recommended the principle of interlocking, it will be seen that very little progress—considering the period which has elapsed since a means of effecting the object has been proposed, for inventors have not been slow in putting their ideas into practical shape—has been made by the railways themselves. No doubt the introduction and application of the automatic brake has been somewhat instrumental in this, affording, as it does, a more rapid and certain means of bringing a train to a standstill. As we have seen, however, this has not always been, efficient as it is, successful in avoiding accidents, and there can be no question that some day, sooner or later, all electrical block signals will of necessity be interlocked with the mechanical signals.

Spagnoletti's Interlocking System.

Fig. 1, which is a diagrammatic sketch, illustrates practically the system adopted by Mr Spagnoletti. A is the station at which the lock is fixed, B that at which the treadle in connection with the rail is placed, *d* is the treadle, *e* the signalling key of the instrument at B, by means of which the line clear signal is rendered at A and the "lock" taken off, so that the man there may move his signal lever; *f* and f^1 are two electro-magnets with their respective armatures, *g*, g^1, each being provided with an independent battery; from *g* there proceeds a wire to the spring, *h*, from the opposite spring of which is carried the line wire proceeding to the signal post, A. There the wire divides, one portion being connected to the stud, *i*, and the other to the electro-magnetic relay, *k*. The electro-magnet, *l*, which

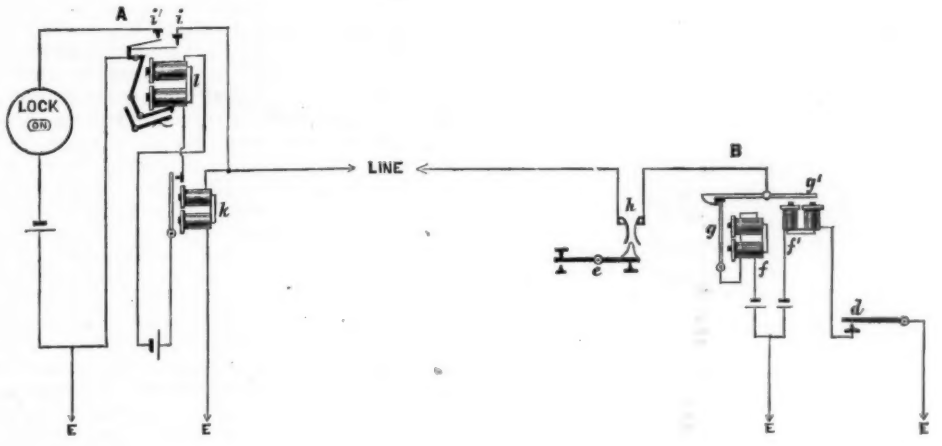


FIG. 1.

controls the lock is placed in the local circuit of the relay, *k*.

The action of the electro-magnet, *l*, is more fully shown in figs. 2, 3 and 4. S is a stiff spring pressing upon the rectangular piece, L, the object of which is to lift another rectangular piece, C, off the pin, P, upon which it normally rests. To the armature, A, is attached one end of the rectangular piece, C, by a loose connection, so as to admit of its movement to and fro of the electro-magnet. To the upper end of A is attached two springs, *i*, i^1, the object of which is to form contact with the studs which are similarly lettered, whilst the lower end of A is so arranged that when in the position shown in figs. 2 and 3, it shall rest upon the block, D^1. This block is movable when free from A, whilst the lower block, D, is rigid. To the slide bar of the signal lever is attached a block, B.

Now let us assume that fig. 2 is the normal condition. The signal lever is free to move. On its being put back into the "on" position it will press against L, and the position of the several parts will then become that shown in fig. 3. That is, the lever will be thrust back into its "on" position, and the slide bar of the signal lever being controlled by the engagement of the block, B, with that of D^1 it cannot be lifted so long as the armature A is in the position shown.

We will now assume that a current is sent through the coils, *l*. The armature, A, is now attracted, and the

position is that shown in fig. 4, Contact is made with the springs, i, i^1, and the block, D^1, is now free to be moved, so that the signalman can pull off his lever if he desires to do so.

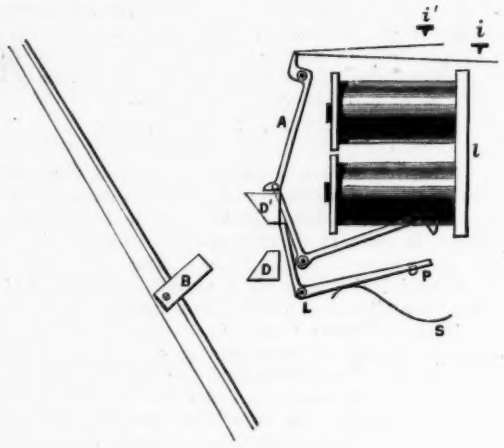


FIG. 2.

Fig. 2 then represents the condition of the locking arrangement when the lever has been pulled off, and no current is passing through the coils ; fig. 3 that when the lever is placed back into its "on" position, and

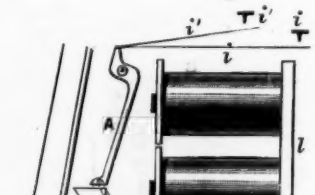


FIG. 3.

fig. 4, that when the "all clear" signal is rendered from a distant station, to admit of the signal being taken off.

At station B there is placed an instrument containing

FIG. 4.

the two electro-magnets, f and f^1, the armature, g^1, carries an insulated piece at its extremity so that when the two armatures, g, g^1, are in the position shown in fig. 1 no current can flow along the line to the spring, h, but on a train passing over the treadle, d, the circuit of f^1 is completed, and g^1 is drawn down. This releases the armature, g, of the electro-magnet, f, and it, falling back under the influence of the spring provided for that purpose, then forms contact with the nose of the hooked piece at the end of armature, g^1. A current can now be passed along the line wire as far as h, and the signalman at B has power, on depressing his key, e, to pass this current on to the relay, k, at A. His doing so releases the block at A, by placing the locking gear at that post in the position shown in fig. 4, under which, as has already been explained, the signalman is at liberty to pull over his lever and admit the train.

The treadle employed by Mr. Spagnoletti is a metal lever provided with two contact springs. The lever is placed under the railway metal and contact is formed by the depression of the rail acting upon the lever as the train passes over.

ELECTROLYSIS OF ALUMINIUM SALTS.

By ALEXANDER WATT.

(*Concluded from page* 30.)

III. *Experiments with Fused Aluminium Salts.*—70. Having been unsuccessful in obtaining metallic aluminium from solutions of its various salts, in a more or less concentrated condition, it was determined to try the effect of electrolysing fused salts of the metal with, and without, the admixture of other substances. The operations were generally conducted in plumbago or clay crucibles, with anodes of platinum or carbon, the negative electrode being either of brass, gilding metal or platinum. As in the former cases, the deposit received upon each plate, after a short immersion, was dissolved off, and the solution thus obtained tested for aluminium ; successive plates were immersed in the fused mass until no further deposit could be obtained upon the last one. In the present experiment a quantity of commercial potash was put into a hessian crucible, which was then placed in the centre of a clear fire ; as the material melted, fresh additions were made until the vessel became about three parts filled. Dried and powdered hydrate of alumina was then introduced, a little at a time, which became rapidly dissolved in the liquid mass. The gradual supply of dry hydrate was kept up until the mass began to thicken, when it was gently stirred and then allowed to repose for a few minutes. Finding that the mass still remained in a semi-solid condition, a small quantity of potash was cautiously added, until it again assumed the liquid form. The electrodes were now carefully immersed in the fluid mass and allowed to remain undisturbed therein for a few minutes ; the negative plate was then withdrawn and examined. The first film obtained upon this plate (a strip of sheet brass) was of a dull black. Assuming this deposit to be due to some metallic impurity of the alumina, the plate was washed and laid aside, and another plate substituted. On dissolving and testing the first deposit, it proved to be iron. The second plate was allowed to remain in the fused bath for about a quarter of an hour ; it was then removed, when a thin blackish film appeared on its surface. This deposit, which gave only a slight trace of iron, also exhibited the presence of other metals, the nature of which was not determined for the reason before given. A third plate was immersed, and since this failed to receive any deposit whatever, the current was increased, and a platinum cathode substituted. No deposit, however, could be obtained even with a greatly increased strength of current. A zinc cathode was next tried, but this only received a faint trace of metal upon its surface.

71. In this experiment a quantity of potash was fused as before, and finely-powdered kaolin gradually introduced ; the earthy matter was rapidly taken up by the fused alkali, and as each portion became dissolved,

a fresh addition was made, care being taken not to add too much kaolin at a time lest the liquid should become chilled by the cold powder and assume a solid condition. When the alkali approached the point of saturation, the mass became thickened, as in the former case, when a small lump of potash was added, which in a few moments rendered it again fluid. The electrodes were then introduced and a strong current allowed to pass; a white film at once appeared upon the cathode, which, however, soon turned black. After a few minutes the negative plate was withdrawn and plunged into cold water. The film, which was dull and black, gave no trace of aluminium, but iron and silicon were both present. A second plate was then immersed, and allowed to remain in the bath for a much longer period. As before, a white coating first appeared upon the plate, but this soon blackened, however, and after about half-an-hour or so the plate was found to be covered with a dense black layer, while black matter of a similar character—which had become dislodged from the plate—floated in the bath. The deposit exhibited no trace of aluminium, but iron, silicon and traces of other metals were found. After several plates had been immersed the bath gradually ceased to yield a deposit of any kind.

72. Borate of soda was next added to the above and the whole kept in a melted state, but this salt did not promote the deposition of aluminium.

73. A quantity of potash alum was placed in a crucible and gently heated until the material became liquified; a small quantity of water was then added to make up for loss by evaporation. On immersing the electrodes—two strips of platinum—a slight film was at first obtained upon the cathode, but this soon ceased to appear; strips of brass and zinc were subsequently immersed but no metallic deposit could be obtained. Borate of soda was then added and the mass well stirred. No deposit of aluminium, however, resulted. A strong current was used.

74. Ammonia alum was also employed in a fused state, but beyond mere traces of metallic impurities no deposit could be obtained. Various substances were added to the fused mass, with a view to promote the deposition of aluminium, but all were without avail.

75. Sugar was added to fused aluminate of potash, but this substance did not assist the deposition of aluminium.

76. A quantity of caustic soda was fused in a crucible, and dried and finely-powdered hydrate of alumina gradually added until the mass began to thicken, when a small quantity of soda was added to re-liquify the mass. As in the former case, the negative plate received a slight metallic film, but after a short time this ceased to appear upon a newly-prepared plate. Various substances were added to induce the aluminium to deposit, but every attempt in this direction was ineffectual.

77. A mixture of the chlorides of sodium and potassium was placed in a plumbago crucible and fused; finely powdered kryolite was then introduced, in small quantities at a time, and the heat kept up. In a few minutes vigorous intumescence set in, the mass becoming thick, and rising to the top of the crucible. The cause of this intumescence was traced to the kryolite having acted upon the silicious clay of which the plumbago crucible was partly formed, whereby the graphite of the vessel became disintegrated. A half-inch copper rod was used as the negative electrode, and a bar of carbon for the positive. Sodium was set free at the negative pole, and, rising to the surface, burned in the air with vivid flashes, accompanied by a crackling sound. No aluminium, however, was deposited upon the cathode.

78. Phosphate of soda was added to fused aluminate of soda. A grey metallic deposit insoluble in hydrochloric acid was obtained from this mixture, but aluminium refused to deposit.

79. To fused potash alum was added, in small quantities at a time, various vegetable acids, as citric, acetic acid, &c., but no metallic deposit resulted from the several combinations.

80. A new bath of fused aluminate of potash was prepared as before, to which was added, in small quantities at a time, cyanide of potassium, the whole being well stirred for a few minutes with an iron rod. On immersing the cathode a white metallic deposit was at once obtained; after a few minutes' immersion the plate was well washed and the film dissolved in dilute sulphuric acid. On applying the usual test the deposit proved to be chiefly iron, but a second metal was also present. The deposit obtained upon the second plate, which was likewise white, was also dissolved off with dilute sulphuric acid, and the solution thus obtained showed no trace of iron, but zinc and some other white metal (not determined) were found to be present. The deposition of these foreign metals gradually became slower, until at last the cathode received no deposit of metal whatever. There was no trace of aluminium.

81. Pyrophosphate of soda was added, in small quantities at a time, to fused aluminate of potash, from which the metallic impurities had been eliminated by electrolysis, but without yielding any advantage, so far as the deposition of aluminium was concerned.

82. Ammonia alum was fused as before, a small quantity of water being added to make up for loss by evaporation; to this was added powdered sal ammoniac, and the whole well stirred. The mixture was then electrolysed, when a dark grey metallic deposit appeared upon the cathode, which, when dissolved in hydro-chloric acid and tested, gave no trace of aluminium. Slight films of a similar character were obtained upon successive plates, but after a short time the molten mass ceased to yield a deposit of any kind.

The foregoing series of experiments only represent a portion of the various trials that were made with a view to deposit metallic aluminium electrolytically, if possible. Many other substances than those referred to were introduced into the various baths, from time to time as they suggested themselves, but in only one or two cases could an actual deposit of aluminum be obtained. It is true that traces of the metal, as I have before stated, were sometimes apparent, but when it was found impossible to obtain a separate, distinct, and unquestionable film of aluminium from any given bath, with or without the introduction of another agent, the trial was necessarily abandoned in each case. The appearance of a beautifully white reguline metal upon the cathodes, in some of the earlier trials, at first led to the impression that this must be due to the metal sought for, but when it was discovered that—while there still remained a considerable quantity of aluminium in the electrolyte—the bath would suddenly cease to yield a deposit after only a small quantity of metal had been extracted from the liquid, it was surmised that the deposits must be due to metallic impurities. From that period each film was examined, with the results shown, namely that in each and every case (with one or two exceptions) the deposit obtained was not metallic aluminium.

Telegraphing in the Jubilee Week.—The Jubilee was the means of realising a wish long entertained by the telegraph officials at St. Martin's-le-Grand, says the *Weekly Dispatch*, viz., that the number of their messages transmitted should reach 100,000. Hitherto the highest figure reached was 90,000. On June 16th, however, this was passed, and 102,032 messages passed through the Central Office. On June 17th the number was 111,000, and on June 20th, 124,291. The messages handed in at one part of London and destined for another part of London numbered on the 20th ult. 30,597—*i.e.*, double the usual number confined to London. These increased figures were caused by the extrordinary number of private engagements that people were making on these days, and the fears that were entertained lest letters might not be delivered with the usual dispatch. Many were sent also to dressmakers and costumiers, urgently requesting them to forward such-and-such articles of attire.

EFFICIENCY TESTS OF A GAULARD AND GIBBS TRANSFORMER.

By P. CARDEW, Captain R.E.

THE excellent articles by Mr. Kapp* on the determination of the lag of primary current behind impressed E.M.F., and of magnetisation behind primary current in a transformer, have been of great service to me, as I happened just at the time that they appeared to be engaged in determining the efficiency of one of these instruments, specially wound and submitted for test by the company connected with Messrs. Gaulard & Gibbs. I was preparing to wrestle with the problem myself when I found this labour saved by the articles mentioned, and as a slight return for this benefit, I give herewith the tests taken with the lags worked out and expressed as angles, and the external efficiency deduced. The tests do not pretend to anything like exact accuracy, as time and the present importance of the question to the War Department did not permit of elaborate precautions being taken. Nevertheless, and in spite of considerable variation in all the quantities measured, the resultant efficiencies are very close, and the sum of the angles, ϕ and ψ, still more strikingly close in all the tests. The turns of the primary and secondary conductors were to each other in the proportion of 4 : 5, which obviously would not be suitable for a practical instrument, but which was very convenient for our means of measuring. The weight of the transformer was about 90 lbs.

The angle, ϕ, is the lag of primary current behind E.M.F., as used by Mr. Kapp in discussing a single magnetic coil. I think it is a pity that he called this ψ in discussing a transformer; ψ is the lag of magnetisation behind primary current. The efficiency is

$$\frac{\text{Secondary current} \times \text{secondary E.M.F.}}{\text{Primary current} \times \text{primary E.M.F.} \times \cos.\ \phi}.$$

The resistances of the two coils were: Primary, $\cdot 023^{\omega}$; secondary, $\cdot 036^{\omega}$. This indicates equal mass of each conductor, in which case the resistances should be to each other in the proportion of the square of the conversion factor, not in the simple proportion, as I think I have seen it stated. The calculated external efficiencies are certainly too high, for the following simple reason, as pointed out by Mr. Kapp, viz., whatever power is absorbed by the iron core should be expressed as current × E.M.F.; the current must oppose the magnetisation, and its ampère turns should be added to those of the secondary current in calculating ψ, making ψ greater and ϕ less than as now calculated. This, of course, will make the number of watts in the primary somewhat higher. It is quite hopeless, I think, to attempt this correction; but, from estimating the radiation from the core, I should put the power wasted at full load at about $2\frac{1}{2}$ per cent., leaving an efficiency of conversion of 97·5 per cent.

However this may be, I consider the results undoubtedly show a very high efficiency for these transformers, and I must say that, in my opinion, great credit is due to Messrs. Gaulard & Gibbs, and the company connected with them, for what they have done in the face of every sort of discouragement to perfect the system, which I am convinced has a great future before it.

The interchange of energy between the transformer and the supplying circuit is a curious phenomenon. When ϕ is appreciable the transformer begins to return energy during a portion of each alternation, and when $\phi = \frac{\pi}{2}$ the energy given to the transformer during one quarter of an alternation is returned during the next quarter, except what is exhausted in heating the conductor. There is a sort of ebb and flow of tide enduring in the case of the last experiment but one, for about $\frac{1}{600}$th second, and only a little leaks out each time. In this experiment the calculated primary watts are 55·4, of which 40·57 are absorbed in the primary coil, and 15·4 in the secondary circuit, so that in this case we get an apparent efficiency of conversion of $\frac{55{\cdot}97}{55{\cdot}4}$, just over 100 per cent., but of course this should be reduced on account of the power absorbed by the iron core. The fact that the primary current absolutely rose to a higher value in this experiment as compared with the previous one is very curious.

The primary circuit was connected to a 32-magnet Wilde machine, the secondary circuit to 50 C.P. 60-volt lamps. In the first series the volts at machine were maintained constant by the engine driver altering his speed to suit the load, and the tests were taken on one Siemens electro-dynamometer and one Cardew voltmeter, by rapidly changing the instruments from one circuit to the other. In the second series an attempt was made to keep the speed constant by altering the strength of field in the machine; but as no suitable rheostat was available and the engine was not governed this could not be exactly effected, and the volts on the primary circuit show considerable variation. Two dynamometers and two voltmeters, however, were used, so that absolutely simultaneous readings were secured. In the third series no attempt was made to keep any value constant, but simultaneous readings were taken. The angle, ϕ, is the lag of primary current behind impressed E.M.F., ψ that of magnetisation behind primary current; their sum as shown is in all cases nearly 90°.

—*Industries.*

TABLE OF RESULTS.

No. of lamps in secondary circuit.		Current.		Volts.		Angles of lag.			External efficiency.
		Primary.	Secondary.	Primary.	Secondary.	ϕ	ψ	$\phi + \psi$	
First series	20	55·3	40·6	50·5	61	22° 26′	67°	89° 26′	95·9 per cent.
	11	42·4	23·1	50·5	60·25	46° 16′ 30″	42° 55′ 20″	89° 11′ 50″	94 ,,
	7	40·4	15·3	50·5	61·5	60° 49′ 10″	28° 15′ 10″	89° 4′ 20″	94·6 ,,
Second series	14	43·9	28·8	46·75	55·75	34° 12′ 10″	55° 5′ 20″	89° 17′ 30″	94·6 ,,
	21	52·3	38·16	43·5	50·5	23° 50′ 30″	65° 30′	89° 20′ 30″	92·6 ,,
	17	53·5	33·5	47	55·5	37° 33′ 20″	51° 30′ 30″	89° 3′ 50″	93·27 ,,
	13	38·2	25·14	45	54·5	34° 0′ 50″	55° 21′	89° 21′ 50″	96·16 ,,
	9	33·3	17·35	47·25	57	48° 39′ 25″	40° 38′ 15″	89° 17′ 40″	95·15 ,,
	23	60·2	40·2	42·5	50	32° 23′ 10″	56° 35′ 10″	88° 58′ 20″	93 ,,
Third series	23	56·7	41·83	43·5	51·5	22° 8′	67° 12′	89° 20′	94·3 ,,
	15	49	34·04	52	63·5	29° 7′	60° 16′	89° 23′	97·15 ,,
	12	46·4	29·81	56	68·5†	35° 58′ 45″	53° 25′ 25″	89° 24′ 10″	89·39† ,,
	9	42·9	20·39	50	60·6	52° 39′ 50″	36° 26′ 40″	89° 5′ 30″	95 ,,
	6	41·1	16·68	56	69·5	58° 41′	30° 29′	89° 10′	96·94 ,,
	3	39·6	7·9	64	79	74° 46′ 10″	14° 26′ 25″	89° 12′ 35″	93·74 ,,
	0	41·8	·2‡	61·2	77	88° 45′ 25″	0° 20′ 35″	89° 6′	27·76‡ ,,
	6	41·9	16·32	50·25	61·33	59° 54′ 10″	29° 8′ 10″	89° 2′ 20″	94·8 ,,

* See ELECTRICAL REVIEW for April 22nd and 29th, 1887. † Primary volts probably read too high. ‡ Estimated current in voltmeter.

NOTE.—The dynamometers were very insensitive for the currents used, it being considered desirable to avoid self-induction in them.

A CONTRIBUTION TO THE KNOWLEDGE OF ACCUMULATORS.

As the theory and the practice of accumulators are still substantially engaged with the collection of materials, it is, perhaps, not superfluous if I (W. Kohlrausch, in *Electrotechnische Zeitschrift*), by way of a contribution to these materials, describe results yielded by a great number of chargings and dischargings of some accumulators at the works of J. L. Huber, of Hamburg.

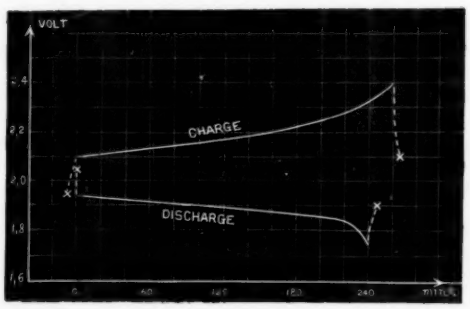
We have to do with accumulators of the form which Huber employs for working electric tramways. The accumulator, of the size of 12 × 16 × 24 centimetres, and of a high shape, weighs 12½ kilos., including the acid. The seven positive and eight negative plates consist of gratings which are filled with red lead or litharge. The plates have a square form, the side measuring 15 centimetres, and the metal of the negative electrodes is lead, that of the positive plates being "Julien metal," an alloy of 4 parts antimony to 96 of lead.

The normal charging and discharging current is 20 ampères, the density of the current is therefore :

$$\frac{20}{7 \times 1{\cdot}5^2 \times 2} = \frac{20}{31{\cdot}5} = 0{\cdot}65 \ \frac{\text{ampère}}{\text{square decimetre}}.$$

The specific gravity of the acid in the charged cells should be 1·2.

Six cells arranged in succession were charged regularly for some weeks in the morning with a current of constant strength (20 ampères), and so discharged in the afternoon through a constant resistance, that the mean strength of the current was about 21 ampères.



The tension, as required, was read off on a torsion-galvanometer every 15 to 30 minutes, and the strength of the current on a spring galvanometer. The mean tension of the open cells before charging was 1·95 volts, at the beginning of the charging 2·1 volts ; it increased during charging (which on an average required 260 minutes) steadily to 2·2 volts during the first 160 minutes, and then with a gradually increasing speed to 2·4 volts, at which value the charging was interrupted. At 2·35 volts the first perceptible escape of gas regularly appeared. After opening, the tension sunk in a few minutes to 2·1 volts.

Before discharging, the tension of an open cell amounted to 2·05 volts. The discharge, which on an average required 238 minutes, began with a tension of 1·95 volts. It sank pretty equably during the first 200 minutes to 1·85 volts, then gradually more rapidly, especially towards the end, to about 1·75 volts. After opening, the tension of the open elements rose again in a few minutes to 1·9 volts. The figure shows the form of the mean course of the tension, as observed during charging and discharging with 20 ampères.

In what follows I collate the mean values of all the experiments. The charging embraced 89·8 ampère-hours and 196·2 volt-ampère hours. Thence follows a mean charging tension of 2·185 volts. The discharge yielded 81·4 ampère-hours and 153·7 volt-ampère hours, therefore a mean discharge-tension of 1·89 volts. The useful effect in ampère-hours is hence 90·7 per cent., and the useful effect in total electric work 78·4 per cent.

Huber gives the discharge-value as 92 ampère-hours. As I in the course of the investigation observed a continuous slow increase of capacity in the accumulators which were ready formed, but still new, the accuracy of this statement does not seem to me doubtful for accumulators in permanent work, especially as I could have attained a higher value by continued charging and discharging. For the mean value 86·7 of Huber's results and my own there appears a capacity of the accumulators of $\frac{86{\cdot}7}{12{\cdot}5} = 7$ ampère-hours per kilo. of the weight of the filled accumulator.

As the greatest possible value of the mean interior resistance of an accumulator—disregarding its known changes during charging and discharging—there appears in manner readily intelligible :

$$\frac{2{\cdot}185 - 1{\cdot}89}{2 \times 20} = 0{\cdot}0074 \text{ ohm.}$$

A calculation from the dimensions of the accumulator shows a still less resistance.

In conclusion, I must refer to the striking agreement which exists between the values for the useful effect as here ascertained, *i.e.*, 90·7 and 78·4 per cent., and the values found by Von Waltenhofen with Farbaky and Schenck's accumulators, namely, 91 and 78·5 per cent.

PRACTICAL ELECTRICAL MEASUREMENT.

By J. SWINBURNE.

(*Continued from page* 36.)

CALIBRATION OF VOLT AND AMMETERS—(*continued*).

The resistance method of adjusting will often be found most convenient, as the cell switches need 21 leads from the cells, which is troublesome if the cells are a little way off. A further adjustment is necessary if it is wanted to get electromotive forces of exact numbers of volts on the voltmeters, but this is not always required. A sliding contact arrangement or some form of rheostat will do.

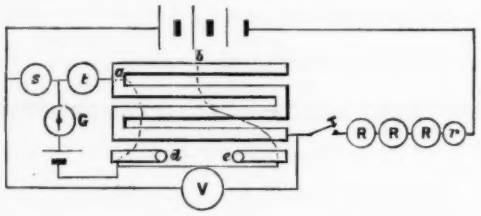
The arrangement being complete for getting any electromotive force wanted by putting in more or fewer cells, or by putting resistance in circuit, the disposition of the standard cell may be considered. As most people have a Wheatstone bridge, a method will first be described in which a standard cell, a bridge, and a galvanometer are required. R, R, *r*, in fig. 23 are adjustable resistances and rheostat coupled up as shown. This resistance box is supposed to have coils for the thousands, so that when all the plugs are out 11,110 ohms are in circuit, *s* and *t* are two specially made up resistances of 143·5 and 56·5 ohms respectively. C is the Clark standard cell in series with a galvanometer, G. The standard cell circuit is from between *s* and *t* to the keys so as to shunt the resistance of 143·5 ohms. If the left hand key is pressed it makes contact with the point *a*, but the right hand key makes contact with *b*, so that if the plugs are drawn between *b* and *a*, there is a resistance of 1,110 ohms in the standard cell circuit. The object of the resistance, *s*, is to make up 200 ohms with *t*, so that the apparatus may be direct reading.

Suppose the voltmeter is to be calibrated up to 100 volts. To get 50 volts on it plugs are drawn in the resistance box to give 4,800 ohms, which with *s* and *t* make up 5,000 ohms. The resistances, R, R, are then adjusted till approximately 50 volts are on the voltmeter. The key, C, is then pressed for a moment. The galvanometer will be deflected showing that there is too much or too little electromotive force. The switches, R, R, R, can regulate within 1 per cent., so that a pair of positions will be found one on each side of the desired resistance. The rheostat, *r*, is then adjusted

till there is no deflection on pressing *e*. The key, *d*, is then pressed and a final adjustment made. The key, *e*, with its resistances are put to prevent a large current passing through the cell in either direction, and the key, *d*, must only be used for final adjustment. The 50 volt reading having been taken, 5,100 ohms are drawn and the 51 volt reading is taken and so on.

The sources of possible error are the heating of the bridge and voltmeter, inaccuracies of observation, and leaks. When the bridge has 100 volts on it and 10,000 ohms drawn, it absorbs one watt, which is not likely to heat the coil enough to cause any serious error. Of this ·4 or ·5 is spent on the 4,000 or 5,000 ohms coil. The heating of the bridge would not cause any error if all the coils, including *t*, rose equally, but the error depends on the difference of rise of the resistance box coils and of the resistance, *t*. There may be a small error due to the cell itself, being at the wrong temperature. The most serious temperature error will probably be in the voltmeter itself. If the voltmeter has a key, and is not meant to be kept on very long at a time, it must be allowed to cool after each reading, because if it were calibrated right through at one operation, its resistance would rise and the calibration would be wrong. During calibration, the voltmeter key must be kept down, or a piece of metal may

FIG. 23.



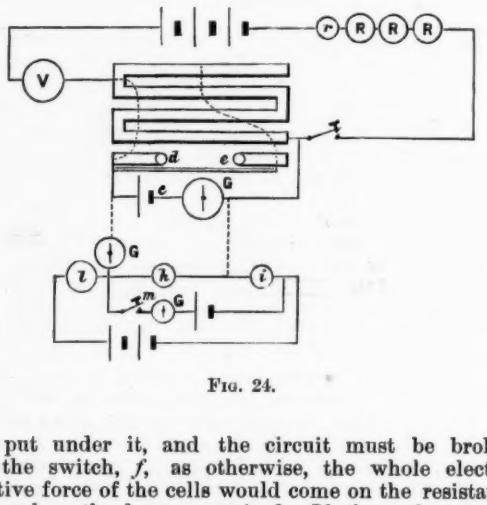


FIG. 24.

be put under it, and the circuit must be broken by the switch, *f*, as otherwise, the whole electromotive force of the cells would come on the resistance box when the key was raised. If the voltmeter is meant for continuous use, and is not of high resistance, it should be left for some time with the electromotive force on it that it is intended to measure, as, for instance, the electromotive force in use at the installation to which it is going. The resistance box should, of course, be out of circuit in the meantime. If the voltmeter is of high resistance, so that it only uses one watt or so, it may be coupled up in series with the resistance box, as will presently be explained. The writer has not used a Wheatstone bridge in the manner described for any length of time: it must, therefore, be pointed out that there may be some danger in putting 100 volts on the coils, as they are wound double so as to have no self-induction, and in the 5,000 ohms coil there will be 50 volts between two wires which are wound together. The coils on most bridges are very carefully insulated, being thoroughly well boiled in paraffin wax, but they are not intended for use with 50 volts on one coil.

If instead of using an ordinary bridge a special bridge is made, it can be made with twenty coils and two circular switches or contact dials, like those already described for regulating the electromotive force, ten coils of 100 ohms each and ten or twelve of 1,000, will give readings up to 100 or 120 volts. The coils should be wound of the same wire throughout, so that they all heat equally with currents of short duration. If they are going to be used continuously they should be made up of different numbers of similar bobbins similarly wound. For all practical purposes it is enough to make all the 1,000-ohm coils alike.

It has been here assumed that the voltmeter is to be calibrated in legal volts. If what are known as B. A. volts are required, *t* must be 145·4 ohms, and s 54·6. The resistance may be measured in legal or B. A. ohms, as it is only a question of the ratio of the resistance of *t* to the whole resistance in shunt to the voltmeter.

If the voltmeter is not to be merely checked, but to be calibrated, the instrument's own scale is not used, but is replaced by a degree scale.

Messrs. Crompton & Co. do not engrave the scales directly on the dials, but on detachable segments. Each segment is fastened on by two screws which are always the same distance apart, so that one segment engraved in degrees will fit any instrument. The readings are noted down and are plotted out on curve paper with the volts and degrees as co-ordinates. The instrument is then graduated from the curve. The segment is screwed on a marking-off plate which has a radial arm and a degree scale, and the segment is marked from the degree scale according to the curve. The curve method is necessary for two reasons. There are always small errors of observation due to the needles sticking slightly or to inaccurate readings, and the curve eliminates these. Many arrangements for calibrating do not, like that just described, give the electromotive force varying volt by volt, but give the electromotive forces at random, and then measure them to some places of decimals. The curve then gives the position for each mark without calculation.

If the voltmeter is of such high resistance that its maximum current will not heat the bridge, it may be put in series. The arrangement is shown in fig. 24. The resistance of the voltmeter at the temperature at which it is wanted accurate is first measured. To know the electromotive force on it, it is then only necessary to know the current. The voltmeter is put in series with the adjustable resistance or battery switches and rheostat, R, R, *r*, and the bridge, as shown. The standard cell is in shunt to the whole bridge.

Readings are taken by drawing plugs and adjusting R and *r* till there is no deflection; thus, if with 287 ohms drawn there were no deflection, the current would be 1·435 ⁄ 287 = ·005 ampère, and this multiplied by the resistance of the voltmeter at the temperature desired gives the electromotive force which would give the same deflection at that temperature. The resistance of the voltmeter must be measured in the same ohms as those of the bridge. The electromotive force will of course be in legal volts if 1·435 is taken as the numerator. The drawback to this arrangement is that it is not direct reading. The simplest way of making the system direct reading is, perhaps, to shunt the voltmeter with a resistance so that the resistance of the voltmeter and shunt is 697 ohms, or some simple multiple of it, ·697 being the reciprocal of 1·435. For every 100 ohms drawn in the bridge there will then be 1 volt or a simple multiple of it on the voltmeter.

The system can also be made direct reading by putting the standard cell on a local circuit. The standard cell, *c*, is then removed, and the leads are put in shunt to the resistance, *h*, as shown dotted, which is on a local circuit with its own cells and rheostat, *l*. The standard cell is in shunt to *h* and *i*, and *h* and *i* are so adjusted that when there are 1·435 volts' fall over them, the fall over *h* gives direct readings with the particular voltmeter being calibrated. The key, *m*, is used to adjust the rheostat, *l*, and the keys, *d* and *e*, to adjust R, R, and *r*. Only one galvanometer is really needed, but two are shown to make the diagram clearer.

THE ELECTRIC LIGHTING OF PASSENGER TRAINS.*

By GEO. W. BLODGETT.

A BETTER method of lighting passenger trains is demanded by considerations of economy, comfort, and safety. Economy is a question which chiefly concerns the railroad management, but comfort and safety concern all their patrons. There are two ways in which we may seek these: either by improving the present system or by substituting a better one. It is doubtful whether oil lighting can be much improved and still be reasonable in cost, and whatever danger attends its use would probably still remain. I have made careful inquiry among my railroad friends without finding any instance within their personal knowledge where the ruins of a railroad wreck were set on fire by the lamps in the train (indeed, these are usually instantly extinguished), but such an instance was said by one of the survivors to have occurred in the late disaster at Hartford, Vt., and another was mentioned at a recent meeting of the New England Railroad Club, where the explosion of a lamp set a sleeping car on fire, and it burned with nearly all the occupants. It is, however, certain that a pile of splinters deluged with oil will burn more fiercely and be much more difficult to extinguish than if in their normal condition.

It is, therefore, desirable to get rid of oil lamps for the harm they may do in *aiding* the progress of a fire, even if they do not cause one. The discomforts of oil lighting, in point of amount, distribution, unsteadiness and colour of the light, corruption of the air, and the great heat given out by a large number of lamps in a car are other reasons why a change would be welcome to both the railroad management and the public, if a reliable substitute can be found. Some of the objections enumerated above apply with equal force to lighting by gas, the others are partially, but not wholly eliminated. *Electricity*, however, offers a means of lighting which comes nearer to meeting all the requirements of a perfect light for passenger cars than any other yet discovered.

There are several ways in which we may produce the electricity for car lighting. It is possible to light a car successfully by any one of them, but further experiment is necessary to determine which is the very best to adopt, and we have already found some much better adapted than others to our American trains. The different methods will be considered in order.

1. By batteries.—I know only one experiment successfully going on at present. A train has been running for nearly a year between Paris and Brussels, the cars of which are lighted by electricity from a bichromate battery. It lasts for five trips of seven hours each—that is, 35 hours of lighting without renewal, which is said to take only five minutes. No accurate estimate of cost or more detailed information is yet at hand. There are several other batteries in the market which appear well, and if the motion of the train does not have a deleterious effect, would seem possibly adapted to this work. My own experience is conversant with only one trial of this kind which did not succeed. Forty cells of a battery which had worked well in several house installations were put up in boxes suspended from the bottom of a car, and 16 (?) lamps of 16 C.P. each put up in the car. The lamps burned well for one night, but the next night there was the appearance of a sudden and enormous increase of internal resistance in the battery, and it was removed for further experiment before trying to light cars. An attempt was made two or three months ago to light a N. Y. C. passenger car with batteries of some kind, which also failed as I am told.†

2. By a dynamo machine.—There are three ways in which this has been done. A small dynamo and engine have been mounted on the boiler or tender, and the latter run by steam from the locomotive boiler. The great objection to this method is that there is no light until the engine is attached to the train, nor if it be temporarily removed. To obviate this difficulty a separate boiler, engine and dynamo have sometimes been carried in the baggage car or on a platform car at the head of the train. It would seem that the danger from fire in this arrangement would be quite as great as by the stoves in the cars. A method tried with some success in a few instances in England and elsewhere abroad (but only once in this country to my knowledge), is to run the dynamo from one of the axles of the train, the proper speed being obtained by suitable countershafting and belts between the axle and the pulley of the dynamo. Since there would be no light when the train is at rest or when the dynamo was running at too low a speed, a battery of accumulators is added, sufficient to keep the lamps lighted for the longest time when the train is standing in the station, or elsewhere. When the train stops, or is at too low a speed for the dynamo to light all the lamps, they are automatically switched to the circuit of the accumulators, where they remain till sufficient speed is again attained, when they are switched back on the dynamo circuit. During the day when the train is running, the dynamo charges the accumulators and keeps them full. They are sufficient to light the train several hours if need be. On one train in Germany the dynamo and 26 accumulators weighed 1,350 pounds, and cost about $625; operating 12 lamps cost about two cents per hour, or one-sixth of a cent per lamp per hour. The London, Brighton and South Coast Railway Company fitted up four trains in this way. In one train of 11 cars there are 32 16-C.P. lamps, absorbing 40 ampères of current. The accumulators are stated to hold 500 ampères (probably 500 ampère hours is meant), and when fully charged are stated to be sufficient to maintain the lamps for eight hours. This train has been running since December 19th, 1883; during the first 11 months it made 2,352 trips, and ran 27,322 miles. No failures are reported. A train on the South Eastern Railway has even run a longer distance. The dynamos on these trains have an E.M.F. of 45 volts and give 56 ampères of current. Two pairs of brushes are mounted on a rocking frame so contrived, that when the train runs in one direction, by means of a lever loosely connected with the dynamo axle, and varied in position by attraction of the pole pieces of the field-magnets, it tilts the frame in the direction to bring one pair of brushes in contact with the commutator. If the train runs in the opposite direction, the other pair of brushes are brought to bear on the commutator. A vessel containing mercury has revolving within it a coarse-threaded screw driven by a belt from the dynamo axle. At each end of the vessel is a vertical tube, at the upper end of which is an adjustable contact screw. When the dynamo and, consequently, the screw revolves in one direction, the mercury rises in one tube. If the motion is reversed, it rises in the other tube, and when it makes contact with the adjustable screw, the shunt circuit of the dynamo is joined up, the field-magnets are charged, the lever is drawn up and one pair of brushes brought to bear on the commutator, which completes the circuit for charging the accumulators. When the lamps are lighted and the train is in motion the dynamo feeds them, the accumulators merely acting as a regulator. If more current is being generated than the lamps require, it goes to the accumulators. If less, the balance is given out by them. When the speed of the train slackens, the fall of mercury in one of the tubes breaks contact with the adjustable screw, the field-magnet circuit is broken and the brushes are removed from the commu-

* Read before the American Institute of Electrical Engineers, June 28th, 1887.

† Most batteries furnish a continuous current for so short a time without renewal that their use is debarred on this account. Some others will not bear the shaking up produced by the motion of the train. I have myself experimented for a considerable time, but thus far without finding a battery which will run on a closed circuit longer than two or three weeks, and at the same time can be carried on a train. When such a one can be found, which at the same time gives a current strong enough to light a series of lamps, it will have a great field of usefulness.

tator, the lamps continuing lighted by means of the current from the accumulators.

The apparatus can be used for several weeks with no attention beyond lubrication, and at the end of this period only a re-adjustment of the commutator brushes is necessary, which puts the machine in condition for a like longer period. The weight of the apparatus is about two tons.

The connections between the cars are made by coupling two cables together. A slightly different arrangement of circuits has the field-magnets of the dynamo wound with two wires in opposite directions, one of which is in shunt to the armature, as if the dynamo were an ordinary shunt machine. The other is wound in the reverse direction as if the dynamo were a compound machine, and the accumulators are in series with this wire. The lamps are also in shunt with the armature.

There is a cut-out to break the circuit of the armature when the dynamo runs below a certain speed; this prevents the cells discharging themselves through it and burning it out. If the dynamo does not furnish current enough for the lamps, the accumulators supply the balance, and in doing so, strengthen the field-magnets and cause an increase of current in the dynamos. When this reaches a greater amount than that needed by the lamps, the surplus goes to the accumulators, and at the same time decreases the magnetism in the field-magnets so as to preserve the balance. At the maximum speed of the machine, the cells are receiving their maximum charge, and the current to the lamps is of normal amount. Two sets of brushes are here necessary as in the other case. Mr. Barrett, of Springfield, Mass., has fitted a train of three cars on the Connecticut River Railroad, with electric lights to be run from a dynamo in something the same way as these just described. The peculiar arrangement of the trucks under an American car renders it a matter of difficulty to obtain the proper speed of the dynamo, and I am told Mr. Barrett has had much trouble with the connections between the axle and countershaft. If these are not kept tight the cable slips. If too tight it breaks. An ingenious device like a friction clamp transmits the power from the countershaft axle to a pulley upon it. This is governed by centrifugal weights balanced by stiff springs. When the dynamo runs at its normal speed these just balance the friction of the clamp and there is no slip. Any increase of speed then causes the friction to diminish, and the pulley slips upon the shaft, till equilibrium is restored. Twenty-four Julien accumulators are connected with the circuit as a regulator, and to keep the lamps lighted when the train stops. A centrifugal governor breaks the circuit of the accumulators when the speed slackens.

A third arrangement of electric car lighting is by accumulators on the train to be charged by a dynamo at a central station or terminus of the road. In England a Pullman train has been running some years, lighted by electricity supplied from accumulators charged when the train is at rest by a dynamo driven by a gas engine. The Pennsylvania Railroad Company experimented more than two years ago with accumulators charged at one end of the line. When the train arrived at Jersey City, the trays containing the cells were removed from the car to a charging room, their places being supplied by spare cells previously charged. The empty ones were charged to be replaced in the first car needing its batteries changed, and these in turn to some other car. The changing of the cells in a car took about 10 minutes. These experiments were in the main satisfactory, but the weak point was the life of the cells, the plates of which after a time buckled and fell to pieces. These cells were furnished by the Brush Electric Company for these experiments, but they declined to send out any more to be used in the same way until the Pennsylvania railroad experiments should be ended.

The estimated cost of fitting a car with 10 lamps and batteries for 70 ampère-hours was about $300 per car.

In the month of January of the present year the Julien Electric Company placed 60 cells of their accumulators in boxes on car No. 90 of the Boston and Albany Railroad, and put ten 16-C.P. lights in the car. These proved to be insufficient, and the number was afterwards increased to 24, of which 20 were on the car and four over the platforms. This car was run some two months as an experiment with such excellent results that in March and April the trains leaving Boston and New York at 4·30 p.m. every day were fitted up with the same system. (These trains are also heated with steam from the locomotive, and there are no fires or oil lamps in any of the cars.) Each coach and parlour car is fitted with 22 16-C.P. incandescent lamps, of which two are over the platforms, 16 in the body of the car, and the rest in the vestibules and toilet rooms. The lamps in the car are arranged opposite each other in two rows in the top of the car, and are on two circuits entirely independent of each other, each of which has a switch of its own by which the lamps may be turned on or off. The platforms are so arranged as to be lighted from either end of the car. They may, if desired, be lighted only just before reaching a station and extinguished just after leaving it.

Sixty cells of Julien accumulators are arranged in boxes under the car, 30 cells on each side. The weight is about one ton. The boxes are neat and ornamental in appearance, and the 30 cells on each side of the car are entirely independent of those on the other side, and are separately wired as far as the switchboard.

The cells have a capacity of 150 ampère-hours and 60 volts on each side of the car. As 60-volt lamps are used, the accumulators on either side of the car will run all the lamps, but, of course, for only half the time the whole will do it. They are arranged in trays of six cells each, furnished with handles; they weigh 200 lbs. and can be raised from the ground and put in the car by two men. The trays are fitted on the outside with stiff brass springs, which, when the trays are in place, bear against each other, and form the connection between each tray and the next. When the trays are in place in the boxes the connections are all made. There are, therefore, no wires to disjoin or connections to make when it is desired to remove a tray for examination or otherwise. From the boxes on each side of the car wires are carried underneath the car to a switchboard in one of the toilet rooms, which also receives the terminals of the lamp circuits. The switchboard is so arranged that the number of cells in use can be varied from 27 in series to 30 in series, the others being added from time to time to keep up the candle-power of the lamps as the E.M.F. of the cells falls. Experiments are now being made to do away with the necessity for this, and if it is found practicable it will be discontinued.

Two terminals underneath the middle of the car on either side serve to connect by means of plugs a pair of cables connected with wires leading to a dynamo in a lighting station a little way off. These terminals are of different size so that no mistake can be made in the connections. When the accumulators are charged the whole 60 cells are placed in series, when they are connected to the lamps there are two series of 30 cells coupled together. In order that there should be no confusion or errors in doing this, I designed a switch which should, by a single movement in one direction of four levers coupled together, throw all the cells in series and connect them to the dynamo circuit. In this position they are entirely detached from the lamp circuits and no current can pass to the lamps. When this switch is thrown in the opposite direction the cells are cut off from the dynamo, coupled in two series of 30 cells each, and connected to the lamp circuits, which, however, do not light until turned on by the special switches for that purpose.

It is quite unlikely that an accident to either of the lamp circuits or the batteries on one side of the car would disable the other. By turning out the lamps on one circuit, therefore, the others may usually be kept burning till the train arrives at its destination. In two

instances this arrangement of circuits has proved very valuable.

All the cars except one are fitted with Weston incandescent lamps said to take 1·1 ampères. The remaining car has Edison lamps, which are proving so satisfactory that it is quite probable all new work will be equipped with the Edison apparatus. The cost is also much less than that of the Weston lamps.

When the train arrives at Boston it is put on a side track near which a line of poles has been set, and the dynamo wires strung upon them. Opposite each car a pair of terminals serves to make connection with the car, and the charging begins. A current of 18 ampères is run in for several hours, dropping to 12 and sometimes 10 ampères toward the end of the charge, which is now 180 ampère hours, to the 60 cells in series. If there were no loss we could draw out 360 ampère hours in the lamps. Assuming that the lamps use 1·1 ampères each, we actually use about 22 × 1·1 ampère × 9 hours = about 216 ampère hours or 60 per cent. of what is put in. If the lamps are required an extra hour or two there is plenty of reserve for them.* The attempt was made to reduce the charge to 140 or 130 ampère hours, but as some of the batteries were not in first-class condition the results were not so good.

The intention is always to have a surplus of current in the battery. For the present the trains run a round trip to New York and return with one charging, but it is not yet quite certain that it can be done in the long nights of winter.

The cost of fitting these cars with accumulators and lamps was, when complete, about $900 per car. Others fitted in the same way would cost less, as on this work the men were all inexperienced, and there were no plans or precedents. The cost of operating the lights is not far from $2 per car per day, or about one cent per hour per lamp. When the lights are needed a longer time, as in the dark days of winter, the cost per lamp hour would diminish. This is about 10 times that of oil, and very nearly the same as for gas, but taking into consideration the amount of light obtained, electricity is the cheapest of the three, and immeasurably the most convenient. The light is very brilliant, well diffused, steady, and satisfactory beyond all expectations. A very noticeable feature of these cars is, the entire absence of heat and the purity of the air, which is as fresh and sweet in the car at the end of its trip as before it leaves the first station; this, together with the absence of danger from fire, especially commends it for sleeping cars.

The Electrical Accumulator Company have also lighted some cars with success for the Fitchburg and Old Colony Railroads at Boston.

The electric light has come to stay. It is the only one which anywhere near fills the conditions of a satisfactory light for railway trains. It can be readily adapted to almost any conditions to be met with in practice.

Oil lamps, and stoves in cars, must follow where the old couplers and hand brakes for passenger trains have gone in this country, until electricity and steam heat have made the roasting alive of scores of people pinned fast in a railroad wreck as impossible as the air brake and Miller platform have made the telescoping of a train into a shapeless mass of ruins, as happened formerly so often. Not many years hence, we may well hope, one will be as uncommon as the other.

Electric Railways in Austria.—An electric railway is being constructed in Graz on the Schlossberg, and a concession has also been obtained for a line from Hainfeld to Ramsau, which will be worked electrically.

* Mr. A. Reckenzaun, in a recent article on storage batteries, gives the average efficiency as not less than 70 per cent. The Julien Company claim, I understand, 80 to 85 per cent. for theirs. Doubtless this can be realised under special conditions, but my own experience would not warrant me in assuming so much in car lighting—at least until the most favourable conditions of use are better understood

THE ELECTRICAL RESISTANCE OF LIQUIDS.

IN the issue for July 8th of our contemporary, *Engineering*, is a letter from Mr. G. R. Bodmer on "The Electrical Resistance of Steel Solutions," in which the author details the results of a number of experiments he has made to determine whether any definite relation can be found to exist between the mechanical or chemical properties of any sample of steel and the electrical resistance of a solution of the same in nitric acid.

Mr. Bodmer found that "Although different samples show different resistances, yet the variations in the latter for steels of very different quality are relatively too small to afford any safe guide, especially as, owing partly to polarisation, but probably still more to the way in which the resistance is affected by any inconstancy in the current, it is very difficult to obtain a perfectly accurate reading." In the course of the experiments it was noticed that "Tests made with half the battery power only, gave a much higher resistance of the fluid than when the whole number of cells was used, and it soon became apparent that the resistance of the solutions varied in some inverse ratio with the strength of the current." With reference to this Mr. Bodmer remarks—"The fact, however, of the resistance of the acid solutions and of the nitric and sulphuric acid also varying in an inverse ratio with the strength of the current, appears to be new." It is, perhaps, almost unnecessary to point out to our readers that this fact (to draw attention to which the letter was written) is not by any means a new one, it being well known to those who have had to deal with cable faults, though it is only comparatively recently that Mr. A. E. Kenelly, in a paper read before the Society of Telegraph-Engineers and Electricians,* pointed out what the exact law of variation was. Mr. Bodmer, in his communication, does not appear to have sufficiently distinguished between the resistance due to polarisation at the electrodes in the solutions, and the resistance of the solutions themselves, or, rather, he has assumed that the resistance of the solutions was really what he was mainly measuring. The measurement of the resistance of liquids is, in most cases, beset with difficulties, owing to the polarisation set up at the electrodes which it is extremely difficult to avoid; this polarisation not only itself causes an actual resistance, but it also causes a spurious resistance due to the back electromotive force which it sets up. In the case of submarine cables the phenomenon known as electrification, as is well known, in an ordinary insulation test, causes the galvanometer deflection to gradually fall, and it is the practice to note the deflection after a certain time, usually one minute, and to speak of the *resistance* after one minute's electrification as if the fall in the deflection were caused by an increase of resistance in the dielectric; it is far more probable that this fall in the deflection is due not to a change in resistance, but to a counter-electromotive force of polarisation set up by the action of the battery. Probably the best method of getting rid of the effects of polarisation is that of working not with a continuous current, but with reversed currents, a commutator being used which, as we have more than once explained, not only reverses the battery, but the testing galvanometer also, the measurement being made by the ordinary Wheatstone bridge method. To make a measurement of this kind perfectly satisfactory, however, it would be necessary that the contacts causing the reversals be of exactly equal duration, otherwise it is obvious that in a given time the sum of all the intermittent currents in one direction will exceed the sum of all the intermittent currents in the other direction, the result being that the two effects will not exactly annul each other. Mr. Bodmer in his experiments attempted to eliminate, as far as possible, the effects of polarisation by wiping the electrodes before each observation, and by taking the measurements as

* ELECTRICAL REVIEW, April 1st, 1887, page 314.

quickly as possible ; although this would no doubt to some extent help towards trustworthy results being obtained, it would not by any means ensure such accuracy as to make the measurements of the required value ; the rate at which polarisation takes place is extremely rapid, even in the $\frac{1}{1000}$th part of a second it is possible, according to Prof. Garnett, for it to be set up. The most satisfactory method of determining the electrical resistance of a column of liquid would, it would seem, be to measure the current passing through the same by means of a galvanometer included in the circuit, and then to measure the potential between any two points in the column, the product of the current and the potential difference giving the resistance. This method would eliminate the effects of polarisation at the electrodes, and there appears no reason why the potential measured between two platinum wires inserted in the liquid column and connected to an electrometer, or galvanometer of high resistance, should not give what is required. The measurement of the current strength would present, of course, no difficulties.

of the air pressure momentarily existing in the main pipe or under the valves, so that what is technically called bleeding the auxiliary reservoirs to release the brakes, or the sticking of the valves for want of sufficient pressure on the engine to release the same, is entirely avoided. 4. The brakes can be *partially* released if, at first, applied with too much force, a feature which not only permits the better regulation of the speed of the train, but also effects a large saving in the amount of air used. Too great stress cannot be laid upon the important advantages accruing through the independent control of the valves hereby furnished, and brakes being at the same time operable by variations in the air pressure, or in other words, the brakes being automatic through air pressure as heretofore, no element of danger or material complication is introduced through the addition of the electrical features."

It may be stated that the electro-magnets used are connected in multiple arc, and that the electric current is used only momentarily while applying or releasing the brakes. The first avoids the necessity of a complete train circuit, that is to say, if the main wires or

Fig 1. Arrangement of Engine & Tender.

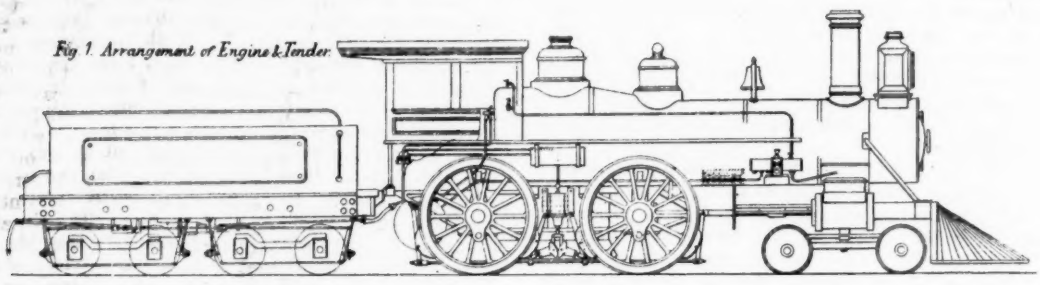
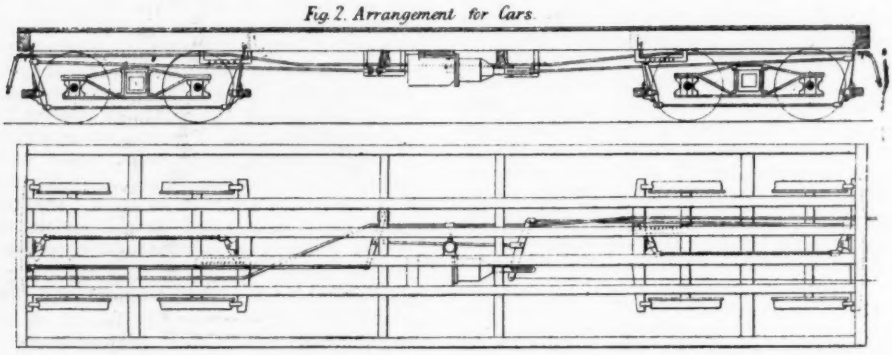


Fig 2. Arrangement for Cars.



THE CARPENTER AUTOMATIC ELECTRO-AIR BRAKE.*

WE give with this article full illustrations of the Carpenter brake, which is among those participating in the Burlington brake tests. It is a continuous automatic air brake, the valves of which are operated either by an electrical current or by variation of the pressure in the main air pipe, or by both means combined. Before referring in detail to our engravings, we will give the claims that are made for this brake by its owners :—"1. The valves, being operated by electricity, can be called into action throughout the longest train instantaneously. This avoids all shock and enables the train to be stopped in the shortest possible distance, or the force used can be graduated with the greatest nicety in making service stops. 2. While working the valves electrically communication is never cut off between the main reservoir on the engine and all the auxiliary reservoirs throughout the train, and, therefore, the air pressure can be sustained or continually replenished, regardless of the length or number of times the brakes were applied. 3. The brakes being released by electricity, the same can be done regardless

* *The Railway Engineer.*

their branches are broken in any portion of the train, the brakes will work up to that point. The second reduces the amount of electricity to such a degree that a battery which, if used on closed circuit would last only a few days, will here serve for months.

Referring now to the engravings, it will be seen that fig. 1 shows the general arrangement for an engine and tender. An air pump placed in any convenient position on the engine compresses the air into the main reservoir ; from thence it passes through the engineer's brake valve to the tender, and from there on to the rest of the train in the usual way. The detail of the brake apparatus used on the tender is the same as that used for the cars. The detail of the driving wheel brake apparatus, being so similar to that in common use, needs no further description. The automatic valve for operating the same is here placed for convenience under the engineer's cab. A small secondary battery, preferably a "Julien" containing from six to eight cells, having one ground connection and one connection to the engineer's brake valve, conveniently located on the engine, furnishes the electrical energy for working the valves throughout the train. The handle of the engineer's brake valves, having a detachable connection with the plug or slide valve thereof, the same can be turned to make the electrical connec-

tion between the battery and the train wire without moving the mechanism used to operate the brakes by air; or the air brake mechanism may be operated without making the electrical connections. The wires extending throughout the train may be laid either within or without the air pipe, but in either case they are contained within the air hose, and the simple act of uniting the latter also completes the electrical connections between the cars.

In fig. 2 the general arrangement of the brake apparatus on the car is shown. The cylinder and auxiliary reservoir are bolted together, the automatic electric air valve being secured directly thereon. The main air pipe with the hose couplings and wires therein completes the equipment, the necessary connections with the brake rods being similar to those used for other air brakes.

Fig. 3 shows in detail the arrangement of the brake cylinder, auxiliary reservoir and automatic valve. This

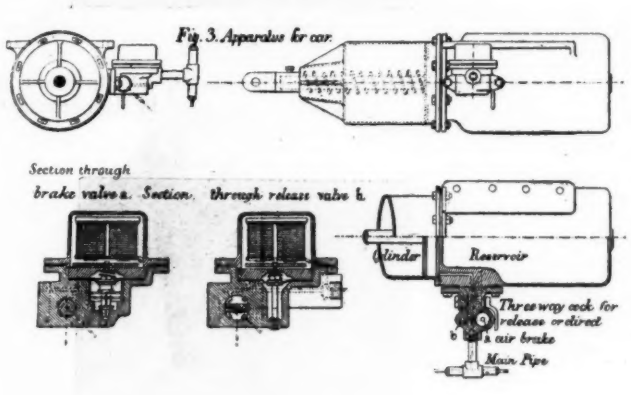
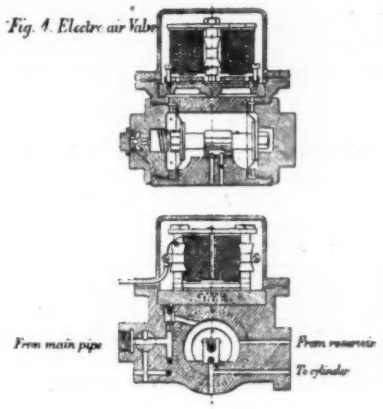
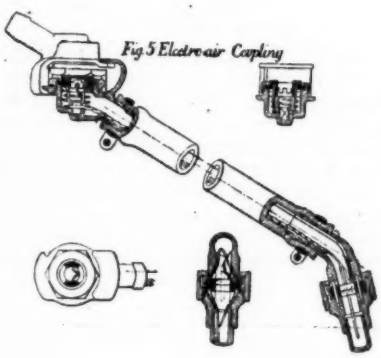
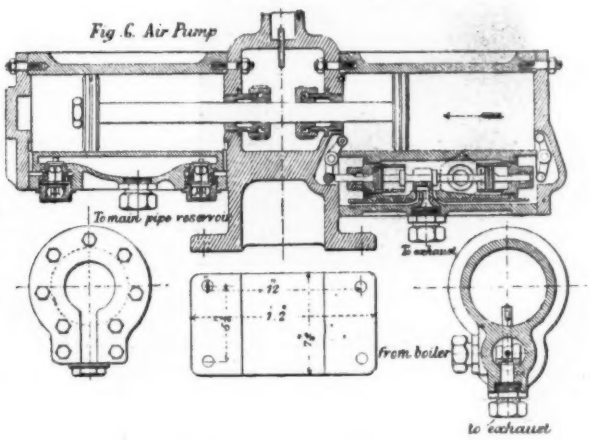


Fig. 3. Apparatus for car.
Section through brake valve a. Section through release valve b.
Cylinder
Reservoir
Three way cock for release or direct air brake
Main Pipe







valvular apparatus contains two distinct main valves as shown in separate sectional views. The first shows section through the brake valve, *a*. This valve is used in applying the brakes, and can be operated either by means of an electric current or by reducing the pressure in the main air pipe. In either case air is admitted from the auxiliary reservoir into the brake cylinder applying the brakes. The other view shows section through the release valve, *b*, which can be operated by an electrical current only to release the brakes. In each case an electro-magnet, being energised by it, will attract an armature and therewith a small tappet valve; this exhausts the chamber above the diaphragm, whereupon the pressure beneath the diaphragm raises the latter, and therewith the brake valve, *a*, or the release valve, *b*, applying or releasing the brake according as the handle of the engineer's valve is thrown forward or backward. To make this valve action clearer we give the following more detailed description:—Referring to drawing (in fig. 3) of section through brake valve, *a*, the air passes from the main pipe to the plug shown by dotted circular lines, thence in between the diaphragm and piston. This presses the piston down; at the same time the air passes through the piston and into the reservoir. At the same time it passes through a small leak hole into the chamber above the diaphragm. The whole box is then charged with air. When the armature is energised by the current passing into the magnet, it lifts a small tappet valve, which blows off the chamber; the air pressure below then raises the diaphragm and the whole brake mechanism, and opens connection to the cylinder. When the valve is dropped by shunting off the electricity, the chamber above the diaphragm is charged again and the valve closes, closing connection between the valve and cylinder, and the brake is applied. Referring to drawing (also in fig. 3) of section through release valve, *b*, in charging the brake cylinder, the valve chamber in *b* is also charged. To release the brakes, the current over the release wire energises the magnet in *b*, which lifts the armature and opens a tappet valve, thus opening connection between the cylinder and the atmosphere, which, of course, throws the brakes off.

The valve shown on fig. 3 while applying and releasing by electricity, is capable only of applying the brakes by variation of the pressure in the main air pipe. The brake cannot be released by raising the pressure in the main air pipe. The construction shown in fig. 4 does, however, accomplish this. It applies or releases the brake either by means of variation of the air pressure or by means of the electrical currents. The principle of construction is substantially the same as that shown in fig. 3. Several other forms of valves are devised, all accomplishing substantially the same result.

Fig. 5 shows the hose connections, which, while differing materially from the Westinghouse coupling, possesses the important advantage of being perfectly interchangeable with it, so that cars equipped with the two different brakes may be coupled together, and as

the valves are capable of being operated either by air or electrically, it is evident that the two brakes can interchange without difficulty. It will be seen that in this coupling the electrical connections lie entirely within the hose, that the circuit is completed by simply joining the air couplings, and that a hose can be readily replaced, no separate joints having to be made for the electrical wires.

Fig. 6 shows the air pump. In any system of air brakes, whether actuated by electricity or in the older way, the air compressor or pump is a most important factor. The Carpenter pump is claimed to be equal in efficiency to the older forms while being simpler. The valve motion is so simple that no description is necessary, but it may be mentioned that there is absolutely no dead point therein.

ON A MODIFICATION OF A METHOD OF MAXWELL'S FOR MEASURING THE COEFFICIENT OF SELF-INDUCTION.

By E. C. RIMINGTON.*

IN "Electricity and Magnetism," §778, Vol. II., Maxwell gives a method of comparing the coefficient of self-induction of a coil with the capacity of a condenser, the connections for which are practically as follows:—D is the resistance, possessing self-induction; the armatures of a condenser of capacity K are connected to the ends of the arm, B. There are keys in the battery and galvanometer circuits. An ordinary balance is obtained by depressing the battery key before the galvanometer key; then A C = B D. The resistances, B and D, are next adjusted so that no

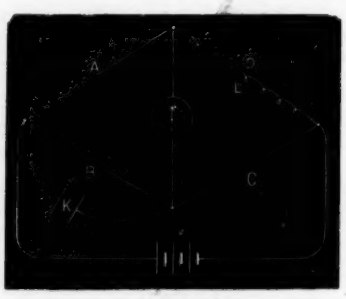


FIG. 1.

momentary deflection shall exist on the galvanometer when its circuit is made before that of the battery. Then L = K B D. This method is very inconvenient, as it necessitates a double adjustment. One of the resistances, generally C, has to be adjusted so as to give an ordinary balance; then, in order to obtain no deflection when the galvanometer circuit is closed, first the resistance, B, will have to be altered, as D is generally the resistance of the coil. This necessitates a fresh adjustment of C, and so on.

The first modification of this method I made was by putting a resistance possessing no self-induction in the arm, D, in series with the coil, as in fig. 2, a slider moving over this resistance and the condenser being connected as shown.

An ordinary bridge balance is first obtained, and the slider is then adjusted until there is no throw on the galvanometer, when its circuit is closed before that of the battery. Then

$$L = K r^2,$$

where r is the resistance between the armatures of the condenser. This method was found to be insensitive, as, unless K were large, r had to be made high. It will not do to make K too large with an ordinary mirror galvanometer, on account of a sort of double throw being obtained, the effect of self-induction being more rapid than that of the condenser, and the galvanometer not ballistic enough. I then adopted the following modification, which answers very well.

FIG. 2.

The arm, B, is a resistance on which two sliders move, one of them being connected to each armature of the condenser, K.

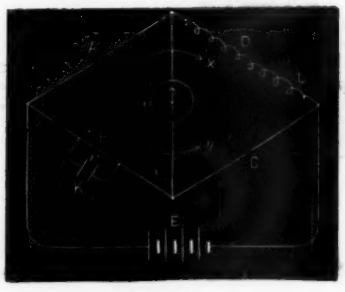


FIG. 3.

Obtain a permanent balance; then A C = B D.

Now adjust sliders until there is also a balance when galvanometer circuit is closed first. Let x be the current flowing in the arms A and D when it has attained its permanent value, and let y be that in the arms, B and C. Let r be the resistance between the sliders when both balances are obtained. Let the battery and galvanometer circuits be both closed, and let the former be broken. The quantity of electricity which passes through the galvanometer due to the self-induction in D

$$= \frac{L\,x}{C + D + \frac{G\,(A + B)}{G + A + B}} \times \frac{A + B}{G + A + B}$$

$$= \frac{L\,x\,B}{B\,(C + D) + G\,(B + C)}, \text{ since } A\,C = B\,D.$$

The quantity which passes through the galvanometer, due to the discharge of the condenser,

$$= K\,y\,r\,\frac{r}{A + B + \frac{G\,(C + D)}{G + C + D}} \times \frac{C + D}{G + C + D}$$

$$= \frac{K\,y\,r^2\,C}{B\,(C + D) + G\,(B + C)}, \text{ since } A\,C = B\,D.$$

Now these quantities obviously pass through the galvanometer in opposite directions; and if there is no throw, they must be equal. Therefore

$$\frac{L\,x\,B}{B\,(C + D) + G\,(B + C)} = \frac{K\,y\,r^2\,C}{B\,(C + D) + G\,(B + C)},$$

or

$$L = K\,r^2\,\frac{y}{x} \cdot \frac{C}{B}.$$

Now $\frac{y}{x} = \frac{D}{C}$; $\therefore \quad L = K\,r^2\,\frac{D}{B}$.

* Read before the Physical Society on May 14th, 1887.

If $r = B$, we have Maxwell's method, and

$$L = K\,B\,D.$$

Of course it is not necessary to use two sliders; one armature of the condenser can be connected either to the junction of A and B or to the junction of B and C, and the other to the slider; but by having B composed of two slide-resistances, the smaller one being equal to the resistance of one of the coils of the larger, and employing a slider on each, a much greater range of adjustment can be obtained.

Suppose r to be slightly out of adjustment by an amount δ. Then the quantity which passes through the galvanometer is

$$q = \frac{K\,(r+\delta)^2\,C\,y - B\,L\,x}{B\,(C+D) + G\,(B+C)}.$$

Now $$y = x\,\frac{D}{C};$$

$$\therefore\ q = x\,\frac{K\,(r+\delta)^2\,D - B\,L}{B\,(C+D) + G\,(B+C)},$$

and since $B\,L = K\,r^2\,D$,

$$q = x\,\frac{2\,K\,r\,\delta\,D}{B\,(C+D) + G\,(B+C)}.$$

If ρ be the fractional error in r, $\delta = \rho\,r$;

$$\therefore\ q = x\,\frac{2\,K\,r^2\,D\,\rho}{B\,(C+D) + G\,(B+C)}.$$

Now $$x = \frac{E}{\rho + \frac{(A+D)\,(B+C)}{B+B+C+D}} \times \frac{C}{C+D}$$

$$= E\,\frac{C}{\rho\,(C+D) + D\,(B+C)},$$

since $A\,C = B\,D$; and $K\,r^2\,D = B\,L$;

$$\therefore\ q = \frac{2\,E\,L\,\rho\,B\,C}{\{\rho\,(C+D) + D\,(B+C)\}\ \{B\,(C+D) + G\,(B+C)\}}$$

$$= \frac{2\,E\,l\,\rho}{\left\{\rho\left(1+\frac{D}{C}\right) + D\left(1+\frac{B}{C}\right)\right\}\ \left\{C+D+G\left(1+\frac{C}{B}\right)\right\}}.$$

If we wish to make q as large as possible for a given value of ρ, we must make C small and consequently B also small. Of course B cannot be less than r, and will generally be a given resistance, depending on the apparatus we are employing. If B is given, differentiating the expression for q with respect to C, and equating to zero, we obtain

$$C = \sqrt{\frac{B\,D\,(G+D)\,(\rho+B)}{(G+B)\,(\rho+D)}}.$$

If ρ is small compared to the other resistances, this gives

$$C = B\,\sqrt{\frac{G+D}{G+B}}.$$

This method can be made much more sensitive by adopting the principle employed by Profs. Ayrton and Perry in their admirable instrument the secohmmeter. A commutator is introduced into the battery and galvanometer circuits, which by its revolution puts on the battery, the galvanometer circuit being closed, breaks the latter, or short circuits the galvanometer and then breaks the battery circuit, afterwards closing the galvanometer circuit, repeating this cycle of operations during each revolution. In this method neither the speed of the commutator nor the fraction of the cycle during which the battery and galvanometer are on together need be known, as is the case with the secohmmeter.

To find the conditions under which a telephone may replace the galvanometer.

In order that the galvanometer may be replaced by a telephone it is necessary that the current through it at any moment shall be zero. Consequently v_1 must equal v_2 always. Therefore the resistance of G may be anything. Let it be infinite, and let x be the current in A, D, C, and $B - r$, y the current in r, and q the charge on the condenser at any moment, t, after the battery circuit is broken.

Let x_0 be the current in D, y_0 the current in r, and q_0 the charge in the condenser at the moment of breaking the battery circuit, and suppose the break is not prolonged by a spark at the contact.

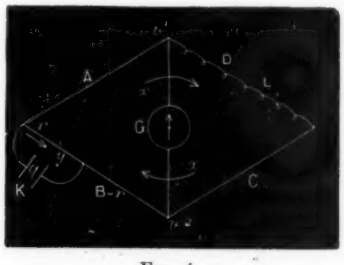


FIG. 4.

Then

$$(C+D)\,x + L\,\frac{dx}{dt} = v_1 - v_2 = 0, \qquad (1)$$

$$(A+B-r)\,x - r\,y = 0, \qquad (2)$$

$$x + y = -\frac{dq}{dt}. \qquad (3)$$

From (2),

$$y = x\,\frac{A+B-r}{r};$$

and therefore from (3),

$$x\,\frac{A+B}{r} = -\frac{dq}{dt}. \qquad (4)$$

Now from (1),

$$\frac{dx}{x} = -\frac{C+D}{L}\,dt,$$

$$\int_{x_0}^{x}\frac{dx}{x} = -\frac{C+D}{L}\int_0^t dt;$$

or

$$\log\frac{x}{x_0} = -\frac{C+D}{L}\,t,$$

$$x = x_0\,e^{-\frac{C+D}{L}t}$$

Again, since the resistance of G may be anything, let it equal zero; then the condenser is discharging through a resistance equal to

$$\frac{r\,(A+B-r)}{A+B} = \frac{r\,\{B\,(C+D) - C\,r\}}{B\,(C+D)},$$

since $$A\,C = B\,D.$$

Therefore

$$q = q_0\,e^{-\frac{t}{K\,r\frac{\{B(C+D)-Cr\}}{B(C+D)}}} = q_0\,e^{-\frac{t}{K}\cdot\frac{B(C+D)}{r\,\{B(C+D)-Cr\}}}$$

and

$$-\frac{dq}{dt} = q_0\,\frac{B\,(C+D)}{K\,r\,\{B\,(C+D) - C\,r\}}\ e^{-\frac{t}{K}\cdot\frac{B(C+D)}{r\,\{B(C+D)-Cr\}}}.$$

Also $$q_0 = K\,y_0\,r \quad \text{and} \quad \frac{A+B}{r} = \frac{B\,(C+D)}{C\,r}.$$

Substituting these values in (4), we obtain

$$x_0\,\frac{B(C+D)}{C\,r}\,e^{-\frac{C+D}{L}t} = y_0\cdot\frac{B\,(C+D)}{B(C+D-Cr}\cdot e^{-\frac{B(C+D)}{Kr\{B(C+D)-Cr\}}}.$$

Also $$\frac{x_0}{y_0} = \frac{C}{D};$$

therefore

$$\frac{1}{r}\,e^{-\frac{C+D}{L}t} = \frac{D}{B(C+D)-Cr}\,e^{-\frac{B(C+D)}{Kr\{B(C+D)-Cr\}}t}$$

This equation must hold for every value of t, hence

$$\frac{1}{r} = \frac{D}{B(C+D)-Cr}, \qquad (A)$$

and

$$\frac{C+D}{L} = \frac{B(C+D}{Kr\{B(C+D)-Cr\}} \qquad (B)$$

From (A),

$$rD = B(C+D) - Cr,$$

$$r(C+D) = B(C+D);$$

$$\therefore\ r = B \text{ or } C = -D.$$

From (B),

$$L = \frac{Kr\{B(C+D)-Cr\}}{B}$$

$$= Kr\left(C+D-r\frac{C}{B}\right).$$

If $r = B$, $\quad L = KBD.$

If $C = -D$, $\quad L = Kr^2\frac{D}{B}.$

As $r = B$ is the only solution possible, the method can only be used with a telephone under the conditions given by Maxwell, and is impracticable on account of the trouble met with in obtaining the double adjustment.

TRIALS OF MOTORS FOR ELECTRIC LIGHTING. 1887—1888.

CONDITIONS.

The Council of the Society of Arts are prepared to award FOUR GOLD MEDALS and FOUR SILVER MEDALS for Prime Motors suitable for electric-light installations.

The medals will be awarded on the results of practical tests, the conditions for which are as follows :—

1. The motors will be divided into two classes, A and B. Two gold and two silver medals will be allotted to each class.

(A.) *Motors in which the Working Agent is also produced.*

Steam.—Ordinary portable or semi-portable non-condensing engines. Ordinary portable or semi-portable condensing engines.
Gas.—Coal-gas or water-gas with producer. Hydro-carbon vapour. Liquid hydro-carbon.

(B.) *Motors to which the Working Agent must be supplied.*

Steam.—Detached engines, non-condensing, without boilers. Detached engines, condensing, without boilers.
Gas.—Engines worked by illuminating or other gas.
Hydraulic.—Water motors.
Air.—Compressed-air motors. Exhaustion motors.

2. Each class will be subdivided into two groups—those declared to develop not more than 10 H.P., and those which will develop more than 10 H.P. and less than 20 H.P. Each motor will be worked at or about the power at which it is entered. [The horse-power herein mentioned is equivalent to 33,000 lbs. raised 1 foot high in one minute, as measured on the brake.]

3. For 4 H.P. and under, the entrance fee will be £10; above 4 H.P., the entrance fee will be £2 10s. per horse-power. The fees to be paid on entry.

4. No competition will be held unless 10 motors at least are entered.

5. In case of no competition being held, the entrance fee will be returned.

6. The council reserve the right of refusing any entry.

7. All engines and boilers must be fitted up in accordance with the regulations of the Royal Agricultural Society. viz. :—

a. All motors or producers subjected to more than a nominal pressure must be fitted with a pressure gauge. Before any motor can be worked, the pressure gauge must be verified by the judges.

b. There is no restriction as to the construction of motors, boilers, or producers, but the judges must be satisfied that the bursting strength of them is at least four times the working pressure, and that a hydraulic test of one and a half times the working pressure has been satisfactorily applied, if considered desirable.

c. Each exhibitor must declare the greatest pressure at which he proposes to work his motor.

d. No old boilers, that is, boilers that have manifestly been at work for a considerable time, will be admitted without special thorough examination and a certificate of safety from the judges.

e. Each boiler, of whatever form or size, must be provided with the following mountings :—

Two Safety Valves, each of sufficient size to let off all the steam the boiler can generate, without allowing the pressure to rise 10 per cent. above the pressure to which the valve is set.

Two Sets of Gauges for ascertaining the water level.

One Steam Pressure Gauge, which must be tested and verified by the judges before the boiler can be used.

A Half-inch Cock, terminating with a half-inch male gas thread, for the purpose of receiving a testing pump.

One Check Feed Valve, immediately attached to the boiler, in addition to the ordinary pump valves, whenever the feed is introduced below the lowest safe water-level, or where there is a length of feed pipe between the engine and boiler.

f. The judges reserve to themselves the power of affixing any gauges that the peculiar nature of the machinery may call for, with the object of ensuring safety and of obtaining information.

g. Exhibitors must be provided with all the appliances necessary for taking the working parts of the machinery to pieces, for examination, should the judges require it.

h. Shafting, belts, gearing, high speed machinery, and any other exhibits likely to prove dangerous, shall be securely fenced and protected to the satisfaction of the judges, but such approval shall not relieve the exhibitor from his own liability.

8. The points of merit considered of the greatest importance are :—

a. Regularity of speed under varying loads.
b. Regularity of speed during the various parts of one revolution, or one cycle of revolutions.
c. Power of automatically varying speed to suit arc lights.
d. Noiselessness.
e. First cost.
f. Cost of first running.
g. Cost of maintenance.

[In estimating the comparative value to be allotted to each of these points of merit, the judges will give due consideration to the characteristics of each kind of motor, steam, gas, water, &c.]

9. The tests will be carried out under the direction of three judges appointed by the Council of the Society of Arts, who will report to the Council, and will confer with them on the awards.

10. The Council will publish the awards in the Journal of the Society of Arts. They reserve the right of publishing descriptions of any of the motors, and the competitors must afford every facility for this purpose.

11. The competitors must take upon themselves, in exoneration of the Society, all claims in respect of damage (if any) resulting from the testings, and must renounce all claims for compensation for any injuries, real or imaginary, that they may incur from alleged or actual imperfection in the arrangements or in the testings, or from any statement in the report or description published.

12. The competition will take place in London about May or June, 1888. Entries must be sent in by the 31st December, 1887.

13. All costs of fitting up and working the motors must be borne by the exhibitor. The Society will provide the brakes, indicators, and apparatus, electrical and other, necessary for making the tests.

14. The Council reserve the right of withholding any or all the medals.

LEGAL.

The United Telephone Company v. The Lancashire and Cheshire Telephonic Exchange Company.—Queen's Bench Division—Wednesday. (Before Baron Pollock, without a jury.)—The litigation in this case arose out of two agreements. The first was dated May 25th, 1881, and it said that the defendants should in their district have the use of the plaintiffs' receivers and transmitters, paying for each instrument annually a rent or royalty of £1. The date of payment was to be January 1st in each year, and it was to be for the whole preceding twelve months, and a proportionate amount for any part of that period. It was found that this hard and fast system of payment was too inelastic, some telephones being very much more valuable to the defendants than others were, and therefore a new agreement was come to. This was dated June 23rd, 1885, and it substituted for the previous mode of payment that the plaintiffs were to receive from the defendants 12½ or 10 per cent. upon the gross receipts of the defendants for exchange work, and this agreement was to be in operation from January 1st, 1885. It was said that the defendants were in the habit of receiving from their customers annual payments in advance. These arrangements were, of course, entered into at all periods of the year, so that some of those which were made in 1884 would have the best part of their term to run in 1885. The principal questions in dispute were under which agreement and how the payments were to be made to the plaintiffs in respect of those arrangements made by the defendants, the payments for which were made for one year, but which were to continue into the following year. The plaintiffs claimed that there was due to them £7,786 and interest. Mr. Finlay, Q.C., Mr. Moulton, Q.C., and Mr. Bremner were for the plaintiffs; and Mr. Aspland, Q.C., and Mr. Lush Wilson for the defendants. A good deal of correspondence was laid before the

Court, and a long argument was addressed to his lordship. Baron Pollock, in the end, said that the case was not entirely free from difficulty, but he thought that all the accounts up to the end of 1884 should be settled on the basis of the old agreement; and any money earned subsequently should be paid for under the agreement of June, 1885. According to an arrangement made it would be referred to an accountant to settle what, upon this basis, was due to the plaintiffs; and there would be judgment for the plaintiffs for that amount with interest at 5 per cent. Judgment for the plaintiffs.

NOTES.

The Inner Temple Lighting.—At the ball recently held at the Inner Temple, the marquees, supper room, &c., were lit throughout with the electric light, a total of 220 lights of 16 candle-power being supplied from a portable Marshall engine and an Elwell-Parker dynamo placed in Mitre Court. In addition to the above there were over 200 lights supplied from the permanent plant which has recently been extended. The work was carried out by Messrs. Drake and Gorham.

Laying down Electric Mains.—Now that the electric light has been introduced at Leamington, the question has been raised, and to some extent debated, whether in the contract with the Electric Lighting Company for laying down the electric tubes a proviso has been included for taking up the tubes should the experiments prove unsuccessful. It will be for the members of the council to answer this question. The original negotiations regarding the introduction of the electric light were conducted by Mr. A. Chamberlain, Birmingham, who acted his part cautiously and carefully. He got liberty to lay tubes, and being in possession of the highway, it may be an awkward business, says the *Gas World*, to compel him to cede possession should the system of lighting he has so warmly advocated prove abortive.

Brush Lighting in Austria.—The Anglo-American Brush Corporation is very busy with private installations over a district extending from Trieste to Görz, Styria, Nether Austria, Moravia, and Bohemia, and is also doing some work in Russia. The electric light, *Industries* says, is rapidly being introduced in factories situated in Gablonz, Reichenberg, and other small towns in the north-eastern part of Bohemia. As regards central station lighting in large towns, very slow progress is being made. There is no Electric Lighting Bill as in England, but municipal jealousy and the timidity of capitalists are operating in the same direction, and delay the introduction of central station lighting.

The Electric Light at Bath.—Last week the market place at Bath was illuminated by means of electricity for the last time, the series of experiments having, it is said, proved a great success. Twenty-four lamps of 1,200 C.P. each were used with brilliant effect, and the lights were carried along the Corridor to Union Street, the wires being neatly fixed over the shop fronts so as to be almost invisible. The whole of the plant has now been removed, for reasons which may or may not appear upon reference to our leading columns.

The Electric Light in Omnibuses.—The London Road-Car Company is trying the experiment of lighting its omnibuses with the electric light. An "Eclipse" battery has been placed underneath the driver's seat of an omnibus running from Liverpool Street to Victoria Station, and supplies a current sufficiently strong to keep alight a small glow lamp of the Swan and Edison type. This gives a light far superior to anything usually seen in public conveyances, and it is said to cost only about one penny per working night, but of how many hours is not stated. When the light is burnt continuously, the cells have to be refilled with the chemicals once every 16 hours.

Thomson-Houston Central Station in Brooklyn.—From this gigantic station power is furnished for 1,000 arc lights in different parts of the city, several series incandescence lamps being also supplied, as well as small motors for running sewing machines, light lathes, fans, &c. Two engines of 300 H.P. each, steamed by six Logan boilers of 100 H.P. each drive the machinery.

Electric Lighting in Spain.—The municipality of Leon offers a monopoly of 50 years for lighting the town with 260 glow lamps of 20 C.P., burning each on an average 2,200 hours per annum, for the sum of £720. The contractor, says *Industries*, will be the only person allowed to fix cables or wires for the purpose of electric lighting, whether for public or private lights. No price is stipulated for private lighting. Tenders, which will be opened on August 6th, are to be on the basis of a diminution of the number of years of the monopoly. Besides the lighting of the streets, the municipal offices are to be lighted by glow lamps of 20 C.P., to be paid for at the rate of about 0·4 pence per hour. The total number of lights likely to be used, including the theatre and private houses, will not exceed 600, but a price of 0·6d. per lamp hour would probably be obtainable.

The Electric Lighting of Brighton Pavilion.—The following tenders have been received for placing in thorough repair and working order the electric lighting installation at the Royal Pavilion in accordance with specifications prepared by Mr. Preece:—Anglo-American Brush Company, Lambeth, £1,510; Marshall and Co., Liverpool, £1,325; Rashleigh Phipps and Merry, 187, Gray's Inn Road, London, £990; Nicholson and Jennings, Old Kent Road, London, £904 10s.; Brighton Electric Light Company, £720; F. Geere Howard, Oxford Street, London, £700; Gülcher Electric Light Company, £650; Bailey and Grundy, Paddington, London, £578; and Maxim-Weston Electric Company, Queen Victoria Street, London, £525. The maximum and minimum prices here given are approximately in the ratio of 3 to 1. How can such differences be possible?

Electric Lighting in Constantinople.—Alluding to our recent intimation (reproduced in an American contemporary) to the effect that Messrs. Shippey Brothers have assured themselves, by treaty, of the monopoly of electric lighting in certain quarters of Constantinople for a pericd of 50 years, and that "the works will be carried out under the auspices of a powerful Turk syndicate, which has been formed for the purpose of introducing electric lighting in Turkey," *Inventions* says: "It is quite refreshing to hear of 'a powerful Turk syndicate' in connection with electric lighting, in fact, it almost reminds one of the Arabian Nights. It is to be hoped that the execution of this important scheme will not necessitate the departure to the Bosphorus of Mr. Arthur Shippey, whose presence in London is so necessary to the proper development of the electric lighting industry."

Electric Lighting in Coal Mines.—Last Saturday a meeting of coal owners and mining engineers of Lancashire and Yorkshire, was held at Manchester for the discussion of the question of electric lighting in mines. Mr. Jacob Higson presided over a large representative gathering of gentlemen interested in mining. What was said to be a new electric lamp, to be called the Sun lamp, was submitted for criticism, and Prof. Story-Maskelyne, Mr. David Urquhart, Mr. John Higson, and Mr. H. F. Pollock, addressed the meeting in favour of the principle of electic lighting in mines. At the close of the meeting the party, on the invitation of Mr. Nicholson, adjourned to the Queen's Hotel and partook of luncheon together. Sir Richard Pollock presided, and Mr. Jackson was vice-chairman. A number of toasts were honoured, including "Electric lighting in mines," proposed by Mr. H. F. Pollock, and responded to by Mr. Fletcher and Mr. Settle, of Darcy Lever

Electric Lighting of the Heriot-Watt College.—Some time ago it was resolved to adopt electric lighting in the class rooms of the Heriot-Watt College, Edinburgh; and tenders have now been received from firms in Edinburgh, Glasgow, and elsewhere, and the various systems have been made the subject of careful inquiry. In the opinion of the sub-committee to whom the matter was remitted, the installation which promises to be of most service is one offered by Messrs. Macwhirter & Co., Faraday Electric Light Works, Glasgow. The total cost, including £200 for storage batteries, is estimated at £1,462.

Central Station Lighting.—The *Moniteur de l'Industrie du Gaz* reports a conversation with an electrical engineer. The editor asked the engineer his opinion concerning the real value of central electric stations. The engineer replied: "At the last meeting of a committee of electricians to which I belong, there were eight of us, and we eight had been consulted in reference to 265 schemes for central electric stations, of which only 11 had been planned out and four were being carried out.

The Lighting of Theatres.—With reference to the fire at the Opéra Comique, the editor of the *Moniteur de l'Industrie du Gaz* appears to think the explanation may be found in a flaring gas jet, and the absence of proper attendance during the performance. He points out that in his experience he has come across an agreement between a theatre and a gas contractor, in which the latter was to supply all the gas-men, but to have no responsibility in case of fire or explosion, and strongly condemns such a system as leading to carelessness, the result of which is in no sense truly due to gas lighting. He also points out that both at the Opera and the Palais Royal, the electric light started fires within a few days of the disaster at the Opéra Comique.

Central Station Lighting in Berlin.—Some large and comprehensive schemes for the extension of the existing central electric light stations, and the establishment of two new ones, have fallen through, writes the Berlin correspondent of *Industries*, the reason being a disagreement between the Town Council and the Edison Company. Hitherto, the fitting-up of the electric light on the consumers' premises has been carried out by the Edison Company; but the Town Council wanted to secure to consumers the right of having the installations fitted up by third parties, the electric light company to supervise and pass the work, for which they were to be paid at the rate of 10 per cent. on the cost, whilst the supervision for work done for the Municipality would only be paid at 5 per cent. on the cost. To these innovations the Edison Company would not agree, and the negotiations were thus brought to a close. The central stations under the management of the town will now be increased so as to furnish current for 40,000 glow lamps. Experience has shown that out of the total number of lamps fixed only two-thirds are ever lighted simultaneously, and therefore the enlarged stations will be able to serve a district containing 60,000 lamps.

A Spanish Torpedo Boat.—The official trial of the *Ariete*, a torpedo boat which has recently been built for the Spanish Government by Messrs. John I. Thornycroft & Co., of Chiswick, took place on Friday at the Lower Hope, below Gravesend. A speed of 26·003 knots was attained by the vessel, and the Spanish officials expressed themselves as being highly satisfied with the manner in which the boat had behaved under trial. The *Ariete* is 147 feet 6 inches in length and 14 feet 6 inches beam; the displacement is about 97 tons, and the indicated horse-power about 1,600. It is propelled by twin screws, with engines and boilers for each screw, and either engine can be worked by either boiler. The torpedoes are ejected by means of compressed air. All the compartments of the boat are lighted by electricity.

Proposed Telephonic Communication between Brighton and Lewes.—The South of England Telephone Company proposes to erect a line of telephone posts, 80 yards apart, for the purpose of placing Lewes in telephonic communication with Brighton. Application for permission has been made to the Brighton Town Council, and the Works Committee resolved to grant permission, subject to the usual conditions, for the erection of posts on the north side of the highway from the south-west corner of the northern portion of the parochial cemetery, but that the wires westward of that point must be carried underground.

Telephone Tenders.—Tenders are invited by the Hornsey Local Board for providing and fixing street fire alarms and laying the necessary insulated wires for same; also for fixing Gower-Bell telephones (these instruments will be provided by the Board) and laying the necessary wires in connection therewith. The Board will provide and lay the tubes for the insulated wires. Plans can he seen and forms of tender and conditions obtained on application to Mr. T. De Courcy Meade, engineer, any day between 10 and 1. Sealed and endorsed tenders to be sent to the offices of the Board, Southwood Lane, Highgate, N., by 4 p.m. on the 18th inst.

Railway Telegraph Offices.—It is stated in the Manchester papers that the Post Office authorities have closed all the public telegraph offices on the Lancashire and Yorkshire Railway. This action has been taken in consequence of a question which has arisen between the Post Office and the company as to the amount of commission to be paid to the latter for the work done by their servants. There are 32 of these offices scattered all over the Lancashire and Yorkshire system, and at the principal stations, such as Victoria in Manchester, and Tithebarn in Liverpool, a great deal of inconvenience is being caused, for the senders of telegrams are obliged to take them to the General Post Office. Before this peremptory action was taken the railway company applied to the Post Office for more time to enable them, if possible, to come to some arrangement, but the Post Office did not feel disposed to accede to the request, and ordered the offices to be closed at once.

[This note, which was omitted last week by an oversight, is referred to in our editorial comments on page 26.—EDS. ELEC. REV.]

In the House of Commons on Friday last, Colonel Blundell asked the Postmaster-General whether the telegraph service had been stopped throughout the Lancashire and Yorkshire line; and, if so, why this had been done. Mr. Tomlinson asked whether the right hon. gentleman's attention had been called to the serious inconvenience occasioned to traders and others by the sudden withdrawal from the Lancashire and Yorkshire Railway Company of the privilege of forwarding and receiving the telegrams of private individuals; and whether the Post Office would take steps, by putting up additional wires or otherwise, to replace the service so discontinued, and in the meantime would suspend the prohibition. Mr. Raikes: I may state that I had an interview last evening with the directors and manager of the Lancashire and Yorkshire Railway Company, and that following thereon there seems reason to expect that an arrangement will be arrived at and that I shall be able to give instructions for the re-opening of the stations on the Lancashire and Yorkshire Railway for the transaction of public telegraph business on Wednesday next.

The Telegraph in Spain.—Towards the end of last week the telegraphic service in Spain was interrupted by storms.

Ayrton's "Practical Electricity."—We learn that Prof. Ayrton's "Practical Electricity" is now being translated into the German and Spanish languages. This is scarcely to be wondered at, for books of the kind are few and far between in any language.

Fires in Theatres.—A fire occurred lately in the new Burg Theatre, at Vienna, where the Imperial and Continental Gas Association fitted up the installation, to be worked from its central station in the Schenkenstrasse. It appears, according to a correspondent of *Industries*, that some of the accumulators were short-circuited by some bell wires bridging across cables running underneath the stage. The accident was due to negligence on the part of the staff, and not to any fault in the design; but fortunately the fire was discovered before any serious damage had been done.

Electric Locomotion in Philadelphia.—The works of Mr. William Wharton, jun., in Philadelphia, were on the last day of June the scene of experiments to test the practicability of applying secondary batteries to the purposes of electric locomotion. Mr. Wharton has been engaged in similar experiments for several months, and latterly he has had the assistance of Mr. Anthony Reckenzaun, of London, and Mr. G. H. Condict, of San Francisco. A track running around a yard 250 feet square had been laid at the works. In one place a hill had been made, approached by a gradient of 5 feet to the hundred, a steeper rise than exists on any street car line in the city of Philadelphia. With its four curves and heavy incline the line in Mr. Wharton's yard was as unfavourable as could have been selected. Two kinds of rails were used, the ordinary street rail and the T rail in use on steam roads, and the motor car ran on one as well as on the other. The car used was one of the People's Passenger Railway, which had done regular service. To this car was attached an electric motor, suspended upon one of the axles underneath the car. The storage batteries, which were manufactured by the Electrical Accumulator Company, of New York, consisted of 84 small cells placed under the seats. The capacity of each cell was 150 ampère hours and was equivalent to two-fifths of a horse-power for one hour for each battery giving a storage energy of about 34 horse-power hours. Thirty-three people crowded the car on its first journey, and the vehicle ran along with perfect smoothness and entirely under the control of the driver, who manipulated a small handle. The car was stopped and started with ease on the straight, at the curves and on the steep grade. It was stopped and reversed instantly and every test applied was answered satisfactorily. The rate of travel averaged from 1 to 10 miles an hour, without noise or vibration and with smoothness. The universal opinion of those who witnessed the tests was that the motor was an entire success. Mr. Wharton proposes to make a more extended trial on a street car track shortly.

Central Institution.—We were glad to see that Mr. Glazebrook's course of lectures, "On the Methods of Determining the Fundamental Standards of Electrical Units," was a success so far as numbers went. About 40 gentlemen attended, among whom were several well known in the electrical world. Mr. Glazebrook is a good lecturer, but his thorough knowledge of the subject leads him to go rather fast at times for his audience. In the case of these summer courses, the lecturer as well as the lectured must, of course, be considered, but we think it rather a mistake to cram the whole course into one week.

Telegraph Cable to Islay.—Colonel Malcolm asked the Postmaster-General on Monday whether, whenever the telegraph cable to Islay required to be renewed, he would consider the advantages offered by the alternative line through the Island of Gigha, and thus afford the advantages of telegraphic communication to the fishermen of that island. Mr. Raikes said that the alternative route for the Islay telegraph cable suggested in his question should receive full consideration, with a view to its possible adoption when the time arrived for renewing the cable.

Trade Catalogue.—Mr. G. Sharples, of Preston, has recently issued a comprehensive illustrated descriptive catalogue of electrical, chemical, photographic, and other scientific apparatus and requirements, forming a quarto book of 88 pages. In the portion relating to telephones, Mr. Sharples refers to his having disposed of his exchange to the Lancashire and Cheshire Company, and explains that he is thus able to offer for absolute sale a limited number of instruments manufactured under the master patents of Bell and Edison.

Felten & Guilleaume.—The new trade list issued by this firm contains some interesting notes on the history and progress of the business which was established as long ago as 1750 by Mr. Felten. The wire works at Mulheim-on-the-Rhine, near Cologne, cover from 35 to 40 acres, a larger area than that occupied by the present Newcastle Exhibition. About 1,500 hands are employed, and the annual production amounts to 35,000 tons. Messrs. Felten & Guilleaume were the first in Germany to manufacture galvanised telegraph wire, and in 1852 they made the first delivery of such wire to the then existing Prussian Telegraph Department. In the following year they were the first on the Continent of Europe to commence manufacturing telegraph cables, and since then they have been closely connected with the development of telegraphy. In the execution of the German underground system they took a prominent part, carrying out successfully the first experimental line of importance, namely, that from Berlin to Halle; and they have since constructed the greater portion of the further extensions of that system. The German underground telegraph line has already attained a length of about 3,260 miles of cable with about 22,300 miles of conductors. By it Berlin is connected with more than 200 of the most important places in Germany, from Cologne to Metz in the west and Breslau to Konigsberg in the east. Since telephony and the electric light have been brought into public notice, Messrs. Felten & Guilleaume have devoted great attention to the construction of the special cables in demand for these purposes. They have been particularly successful with their anti-induction telephone cables, which are said to be practically free from induction and retardation, and can be used both as underground and aerial cables, and are also specially suitable for tropical climates. This cable is in use in the Mersey Tunnel; and we understand that the agents in this country are doing an increasing business in the various productions of the firm.

Specifications Issued.—Improvements in dynamo machines and electric motors, Louis Bollmann, dated 19th April, 1886, No. 5,409; Improvements in the construction of induction apparatus, Ludwig Gutman, dated 24th June, 1886, No. 8,338; Improvements in glass globes or shades and holders for incandescent electric lamps, Henry Lea, dated 29th July, No. 9,793; Improvements in telephonic apparatus, Daniel Boyd and Samuel Williams, dated 30th July, 1886, No. 9,854; Improvements in the methods of constructing conduits, ways, or cases for electrical conductors and analogous purposes, T. O. Callender and C. E. Webber, dated 13th August, No. 10,393; Novel electrical apparatus for use in checking instructions on board ship, H. P. Sherlock, dated 7th May, 1887, No. 6,745; A compound for covering electric wires, applicable also for other purposes, H. W. Merritt, dated 11th May, 1887, No. 6,927; A compound for covering electric wires, H. W. Merritt, dated 11th May, 1887, No. 6,928; An improved telephonic apparatus, C. L. W. Fitzgerald, dated 12th May, 1887, No. 6,957.

Safety in the Paris Theatres.—It is decided that this question does not concern the Chamber of Deputies but the Prefecture of Police, which is possessed of full power to enforce all the necessary steps, and must, therefore, be held responsible for all delays and for their consequences.

The Lartigue Railway in the West Indies.—In the Demerara Court of Policy recently, Mr. Howell Jones asked for a committee to inquire into the Lartigue system of railway, and its suitability to the wants of that colony. The Governor consented to appoint a committee, and promised to obtain all the information he could on the subject in London.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Equitable Telephone Company, Limited.—An agreement of 2nd inst., filed on the 6th inst., provides for the allotment of 600 fully paid "B" shares of £5 each to Mr. Alan Archibald Campbell-Swinton, C.E., of 75, Queen Victoria Street, as part of the consideration for the purchase of patent rights described in an agreement of 21st December, 1886.

Elieson Electric Company, Limited.—An agreement of 2nd inst., filed on the 5th inst., confirms an agreement of the 2nd May, and in pursuance thereof the company will allot to the shareholders of the Electric Locomotive and Power Company, Limited, in liquidation, 35,985 fully paid up shares.

Electric Tramways Construction Company, Limited.—The statutory return of this company, made up to the 2nd inst., was filed on the 5th inst. The nominal capital is £250,000 in £1 shares. The only shares at present taken up are the seven subscribed for by the signatories to the memorandum and articles of association, and upon these no payment has yet been made. Registered office, Royal Insurance Buildings, Crossley Street, Halifax.

Ottoman Electric Works Company, Limited.—The statutory return of this company, made up to the 7th inst., was filed on the 11th inst. The nominal capital is £50,000 in £20 shares, but the seven shares taken by the signatories are the only shares at present allotted. Registered office, 13 and 14, King Street, Cheapside.

CITY NOTES, REPORTS, MEETINGS, &c.

Eastern Telegraph Company, Limited.

YESTERDAY the thirtieth half-yearly ordinary general meeting of this company was held at Winchester House, Old Broad Street, under the presidency of Mr. John Pender, the chairman.

Mr. George Draper, the secretary, having read the notice convening the meeting, the following report was taken as read:—

The revenue for the half year amounted to £331,861 19s. 10d., from which are deducted £83,035 17s. for the ordinary expenses and £43,903 1s. 6d. for expenditure relating to repairs and renewal of cables, &c., during the half year. After providing £6,400 19s. 4d. for income-tax, there remains a balance of £198,522 2s., to which is added £13,091 18s. 2d. brought from the preceding half year, making a total available balance of £211,614 0s. 2d.

From this balance there has been paid—

	£	s.	d.
Interest on debentures and debenture stock	28,758	2	5
Dividend on preference shares ...	20,296	14	7
An interim dividend of 1¼ per cent. on the ordinary shares	47,500	0	0
	£96,554	17	0

leaving a balance of £115,059 3s. 2d., from which £48,000 has been carried to general reserve.

The directors now recommend the declaration of a final dividend for the year ended 31st March, 1887, of 2s. 6d. per share and a bonus of 1s. per share, amounting to £66,500, both payable on the 14th inst., making, with the three previous payments on account, a total distribution of 11s. per share, or 5½ per cent. for the year on the ordinary shares. The balance of £559 3s. 2d. shown at the foot of the revenue account is proposed to be carried forward to the next half year.

The revenue includes £23,400 dividend for the half year upon the company's shares in the Eastern and South African Telegraph Company. Also £2,600 net receipts for the same period on the shares of the Black Sea Telegraph Company belonging to this company.

The several sections of the company's cables and the land lines in connection therewith are in good working order.

The short cable from Gibraltar to Tangiers referred to at the last general meeting was laid on 4th February, thus placing Morocco in telegraph communication with this company's main system. The directors' estimate of the traffic has been fully realised.

Since the last meeting a cable has been laid by the Italian Government in the Red Sea, connecting Massowah and Assab with this company's station on the Island of Perim. This cable brings additional traffic over the company's lines.

In order to further strengthen the company's direct communications with Gibraltar and Malta, and with a view to meet the increasing volume of business arising from the reduction of European tariffs and the opening-up of new sources of traffic, the board have made a contract with the Telegraph Construction and Maintenance Company for manufacturing and laying a new cable from Porthcurnow to Gibraltar and Malta. This cable has become the more necessary as the renewal of the company's concession for the land line through France has for some time appeared to be doubtful. The new cable will be extended from Malta to Zante, so as to give a third line of communication with Egypt, and enable the company to carry by its own cables a considerable traffic which is now conveyed by other routes. The cost of these new lines will be provided without materially increasing the capital of the company.

The directors deeply regret that on the 18th April last the company's cable repairing steamer *Volta* was wrecked on one of the islands in the Greek Archipelago, with the loss of 12 of the crew, including the captain. The Board of Trade have held an official enquiry into the circumstances attending the stranding and loss of the steamer, and have exonerated the company from all blame, finding that the ship itself was in a thoroughly efficient condition. The *Volta* was fully insured, and the directors have entrusted the building of a new steamer to replace her, to the eminent shipbuilding firm of Messrs. R. Napier & Sons, Glasgow.

The directors have decided to issue Four per Cent. Mortgage Debenture stock of the company at par, bearing interest from 1st May last, together with cash payment of £1 in exchange for equal amounts of the company's Five per Cent. Debentures terminable on the 1st August next, with the coupon due that day attached. Debentures not so deposited will be paid off at par on 1st August at the company's bankers, Messrs. Glyn, Mills, Currie and Co., 67, Lombard Street, E.C.

The Mortgage Debenture stock constitutes a first charge on the undertakings and revenues of the company. The amount issuable is, by the special resolution creating the same, restricted to one-third of the share capital from time to time issued and paid up.

The Chairman moved the adoption of the report and the declaration of the dividend recommended.

Mr. George Garden Nicol seconded the motion, which was carried unanimously.

A full report of the proceedings will be given next week.

South of England Telephone Company, Limited.

ON Tuesday an adjourned meeting of the South of England Telephone Company, Limited, was held at Winchester House, Old Broad Street, for the completion of the business before the general meeting held on June 28th. At that meeting it will be remembered the report and accounts were adopted, and it was resolved that in future half-yearly statements of the progress of the company should be submitted to the shareholders. Mr. D. O. Bateson presided.

Mr. Fred. L. Robinson, the secretary, having read the notice convening the meeting,

Mr. H. Roberts moved: "That the sum of £200 be paid to the directors for their services for the year ending April 30th." The motion, he said, required no comment, for they all knew what arduous duties the board had been called upon to perform.

Mr. Marshall seconded the motion.

A Shareholder remarked that he noticed in the balance sheet the directors' remuneration was put at £250.

The Chairman said that was for 15 months' services.

The motion was carried unanimously.

Mr. Marshall proposed: "That the election of the chairman as managing director made by the board on October 28th, 1886, at a salary of £500 per annum from March 18th, 1886, be and is hereby confirmed."

Mr. J. Taylor seconded.

Dr. Ellis did not think it desirable as a general rule that a chairman of a company should be the managing director. He offered no objection under the exceptional circumstances in this case, but he thought at any future time when necessity for a change arose the chairman should not be the managing director of the company. A managing director was more a director by courtesy than anything else, and was supposed to take his directions from other members of the board, to carry out their views, and generally to be more or less subservient, although he had the title of director.

The motion was then carried.

Mr. Bateson was re-elected a director, the auditor, Mr. J. Weise, was also re-elected, and the meeting then terminated.

The Direct United States Cable Company, Limited.—It has been resolved to recommend a final dividend of 2s. per share free of income tax, such dividend to be payable on and after

July 30th, making with the interim dividends already paid 2 per cent. for the year ending June 30th last. Recourse will be had to the interest on the reserve fund to make up the required amount for such dividend. The transfer books will be closed from to-day to the 29th inst., both days inclusive.

Cuba Submarine Telegraph Company, Limited.—The directors recommend a distribution of 8 per cent., and an addition of £4,500 to the reserve, leaving £840 unappropriated.

India-Rubber, Gutta-Percha, and Telegraph Works Company, Limited.—The directors recommend an interim dividend of 5 per cent. or 10s. per share, tax free.

The Telegraph Construction and Maintenance Company, Limited.—This company announces an interim dividend of 12s. per share on the 11th inst.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending July 8th were £3,154, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending July 8th amounted to £3,762.

NEW PATENTS—1887.

9256. "Regulating speed of dynamos on railway trains for lighting the same, &c." J. L. YUBY, H. W. ANDREWS. Dated June 29.

9281. "Raising and lowering or otherwise controlling electric lights for illuminating railway carriages, vans, &c." T. W. HELLIWELL. Dated June 30.

9339. "Compound for insulating telegraph wires." A. WILKINSON. Dated July 1.

9377. "Transmitting submarine signals." F. H. BOYER. Dated July 1.

9396. "Preventing or detecting the use of pieces of lead, iron, &c., instead of coin in operating automatic electric machines." W. E. RICHARDSON. Dated July 2.

9428. "Electric safety lamps for use in coal mines, &c." W. PATTERSON. Dated July 4.

9443. "Switches or commutators for electrical purposes." S. W. CUTTRISS. Dated July 4.

9485. "Telephone transmitters" J. L. CORBETT. Dated July 5.

9497. "Electric circuits and switches for use in connection therewith." H. H. LAKE. (Communicated by J. F. McElroy.) Dated July 5. (*Complete.*)

9515. "Tanning by aid of electricity." E. WORMS, J. BABE. Dated July 5.

9517. "Arc electric lamps." F. DE WOLFFERS. Dated July 5. (*Complete.*)

9598. "Electrical breaking contacts used in working railway signals. I. A. TIMMIS. Dated July 7.

9602. "Magnetic curative appliances." H. W. CALL. Dated July 7.

9613. "Instantaneous closing of water and air tight doors in steam and sailing ships by automatic action of machinery levers and electro-magnets." C. SKIDMORE. Dated July 8.

9637. "Operation of controlling devices by means of the thermic effects of electric currents." B. DRAKE and OTHERS. Dated July 8.

9645. "Applying electricity to steam and other boilers, compressed air machines and gasometers for preventing explosions and for automatically supplying the feed water to boilers." F. MARTENOT. Dated July 8.

9654. "Galvanic batteries." J. J. SHEDLOCK. Dated July 8.

9685. "Boxes or tanks for galvanic batteries, &c." D. A. DAVIES. Dated July 9.

9725. "Dynamo-electric machines." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12.

9726. "Armatures for electric generators." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9727. "Commutators for electric machines." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9728. "Electric converters and boxes for same." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9729. "Electric converters." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9730. "Voltmeters." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9731. "Ammeters." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9732. "Electrical indicators." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9733. "Regulating electric circuits and apparatus therefor." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9734. "Transmitting electricity from sources distant from where they are to be utilised." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9735. "Electrical distribution." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9736. "Connecting alternate current electric generators and apparatus therefor." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9737. "Electrical distribution and conversion." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9738. "Electrical distribution and conversion." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9739. "Electric circuits and automatic controlling apparatus therefor." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9740. "Electrical distribution." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9741. "Electrical distribution or apparatus for supplying or distributing electricity to electric railways, incandescent lamps, &c." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9742. "Circuit controlling apparatus for electric circuits." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9743. "Incandescent electric lamp sockets." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9744. "Electric conductors or cables." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9745. "Converting electric currents into currents of differential potential." W. P. THOMPSON. (Communicated by G. Westinghouse.) Dated July 12. (*Complete.*)

9758. "Switches for electric circuits." A. C. COCKBURN, E. THOMAS. Dated July 12.

9761. "Conveyor of telegraph and other wires on and under ground." F. BISHOP. Dated July 12.

9767. "Repairing incandescent electric lamps." J. B. DUNCAN. Dated July 12.

9768. "Electrical conductor for the prevention of boiler explosions." J. HEWITSON. Dated July 12.

9773. "Automatic electrical apparatus for signalling trains on railways during foggy weather and snowstorms." E. RESTIEAUX. Dated July 12.

9810. "Bleaching by electrolysis." B. J. B. MILLS. (Communicated by W. E. Smith.) Dated July 12.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1886.

4662. "Improvements in the automatic electrical distribution and charge of secondary batteries." F. KING. Dated April 2. 11d. Claims:—1. A combination of apparatus for automatically charging and discharging two or more secondary batteries or sets of secondary batteries at the proper times without interrupting the charging and discharging circuits, substantially as described. 2. In apparatus for effecting automatically the charging and discharging of two or more secondary batteries or sets of secondary batteries the combination therewith of the apparatus for indicating the completion of the charge of the said batteries, the said indicating apparatus being arranged to operate, substantially in the manner described and illustrated in the drawings. 3. In apparatus for alternately and automatically charging two or more secondary batteries or sets of secondary batteries, the combination of a bye-pass relay and resistance in connection with the charging main and relays and their contacts, substantially as and for the purpose described with reference to the drawings. 4. In apparatus for alternately and automatically discharging one or both of two or more secondary batteries or sets of secondary batteries, the combination of rocking switches, charge indicators, potential indicators, relay magnets, and contacts, and the circuits connecting the same, substantially as described and illustrated by the drawings. 5. The general constructions, combinations, and arrangements of apparatus for automatically charging and discharging two or more secondary batteries or sets of secondary batteries without interruption of the distributing main circuit, as described and illustrated in the drawings.

6574. "Improvements in electric burglar and fire alarm apparatus" Dr. SIGFRIED TAUSSIG. Dated May 15. 8d. Consists essentially of a clock mechanism on the premises of each subscriber; which mechanism is arranged in combination with a local circuit extending to all the points to be guarded, and operates in such a manner that, when one of the contact devices placed in this circuit is actuated by the unauthorised opening of a door, the weight of a person entering a room, the drilling of a hole in a safe, or by the outbreak of a fire, an electromagnet in connection with the clock mechanism is energised. This magnet then attracts its armature lever and disengages the clock mechanism, so a to allow the latter to operate, whereby a contact wheel in the main circuit is caused to rotate and send, during its rotation, a series of impulses to the central station to indicate the place from which the signal is sent. The claims are 3 in number, and the apparatus was illustrated in the REVIEW for December 24th, 1886.

7080. "An improvement in arc electric lamps." W. R. JOHNSTON. Dated May 26. 4d. Claim:—The use in electric arc lamps of a rigid helically coiled positive carbon rod surrounding a straight negative carbon rod, the two rods being made of equal diameters, and the helical rod being coiled to such pitch that in consuming its extremity will always remain in the same plane with the extremity of the straight rod, so that the electric arc will pass from the extremity of the one to that of the other, substantially as described.

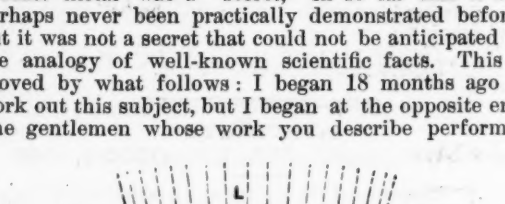
7189. "An improvement in primary voltaic batteries." J. E. PEARCE. Dated May 28. 8d. Claim:—The construction and use of a primary voltaic battery cell consisting of a closed shallow vessel or tray which contains a horizontal plate of metal to form the one electrode, a horizontal slab of carbon with holes or projections presenting extended surface, to form the other electrode, and a solution of a salt of the metal such as chloride covering the metal and moistening the carbon, while chlorine or such other gas as forms with the metal the salt in solution, circulates through the cells in contact with the carbon and the solution, substantially as described.

CORRESPONDENCE.

Sunlight and Selenium.

In your article in this week's ELECTRICAL REVIEW on the effect of sunlight on selenium, is not the fact that the current is stronger when sent in one direction than when sent in the other direction through the combination described, only a proof of what you mention in the last paragraph, namely, that electrical polarisation, or a tendency to a current, is set up by the direct influence of the sun's rays, this current acting *with* or *against* the battery current, according to the direction in which they are coupled up, and thus causing a marked difference between the two results?

The fact that a current is caused by the action of sunlight on a combination of selenium in contact with another metal was a "secret," in so far that it had perhaps never been practically demonstrated before; but it was not a secret that could not be anticipated by the analogy of well-known scientific facts. This is proved by what follows: I began 18 months ago to work out this subject, but I began at the opposite end. The gentlemen whose work you describe performed



G, gold leaf; G', gold plate, or copper gilt on the upper side; L, light rays; C, collector; S, crystalline selenium.

an experiment and obtained a result, and are now looking (perhaps) for the cause which brought about that result. I was in search of a result (the same result), performed my train of reasoning, collected my materials (the same materials) and only just fell short of obtaining the desired result through an accident which caused the loss of my gilding solution (I proposed to electro-gild the surface of the selenium instead of using gold leaf). I think that the experiment which has been performed is a proof that my reasoning was right, and it is even more conclusive and satisfactory to me (from a scientific point of view) than if I had obtained the result myself.

I was in search of a method of using sunlight direct to do our work, instead of using the stored up energy of sunlight, contained in coal, &c. I believe in the atomic theory and the electric polarisation of atoms. By this theory and reasoning by analogy, from results known to be obtained in the thermo-electric battery, I thought that alternate plates of selenium and some other metal with their junctions alternately in the light and in the dark, would give a current. A difficulty at once arose from the fact that metals will not transmit light to any great extent, and therefore it was only possible to apply light all round the outside of the junction of two plates joined end to end, whereas in the thermo-electric battery the heat is distributed by conduction over the whole surface of the joint. This led to the devising of the form which I now describe in words copied from my note book and written at the time of the experiment (December 1885), "Coat a bright plate of metal (preferably gold) with a thin layer of crystalline selenium, coat this with a thin gold leaf which will transmit light, it must be in metallic connection with the selenium, care being taken not to approach the edges and thus short circuit with the other gold plate; or instead of the gold leaf, deposit metallic gold electrolytically on the surface of the selenium, taking care to leave a margin of about one-fourth of an inch all round by coating with a non-conductor. By allowing a strong light to fall on the surface of the thin layer of gold and connecting a wire conductor to the backing plate and another to the thin surface of gold, a current should be obtained and maintained as long as the light falls on the surface. The metals should be circular, and a narrow flat ring, the full size of the thin layer of gold, should be laid on that surface to collect the current."

The following was my tabulated method of proceeding:—

"To form photo-electric pile.—1. Gild daguerrotype plate on face.

"2. Apply a layer of selenium to the surface and crytallise it there.

"3. Coat the surface of the selenium with a layer of gold by electro-gilding process (thin enough to transmit light).

"4. Fit the daguerrotype plate in case and fix there.

"5. Fit the collector over gilt surface."

As before stated, I carried out the above till I came to the gilding, and then, in heating the solution, the vessel was broken and the liquid lost. Gold is used because when thin it transmits light. A number of the above connected in series should give a fair current; they would require no attention, the cost of maintenance would be *nil*, and they might be protected from dust, &c., by a covering of glass.

William H. Phillips.

July 9th, 1887.

Sabine's "Electric Telegraph."

In reading Sabine's "Electric Telegraph," I notice an error in the portion relating to "Science and Practice," page 263, which may be worth pointing out.

Speaking of the arrangement of batteries to obtain the maximum current, the formula given to find the number of rows is given thus:—

Let N be the number of cells, r the resistance per cell, the external resistance R, the number of rows x. The author says:—"We must arrange x rows of each $\frac{N}{x}$ elements parallel. The resistance of each row must therefore be $\frac{R}{x} = \frac{r\,x}{N}$, whence the number of rows $x = \sqrt{\frac{N\,R}{r}}$." (I have substituted R for the Greek ρ.)

He gives a numerical example which, when worked out, gives an internal resistance of 1 ohm, while the external is 16, thus violating the conditions of the law he mentions. The formula and the example are both wrong.

The correct formula is arrived at thus:—

The number of cells in each row is $\frac{N}{x}$.

The resistance of each row is $\frac{N\,r}{x}$.

The joint resistance of the rows must = R.

Therefore that of each row must be R x,

$$\therefore \ \mathrm{R}\,x = \frac{\mathrm{N}\,r}{x} \text{ or } x = \sqrt{\frac{\mathrm{N}\,r}{\mathrm{R}}}.$$

The example has $\mathrm{N} = 100$, $r = 4$, $\mathrm{R} = 16$, and the author gives the number of rows as 20. It should be 5.

The number of cells per row may be calculated thus :—

Let y = number of cells in a row.

$\frac{\mathrm{N}}{y}$ = number of rows. $y\,r$ = res. per row.

$$\frac{y\,r}{\frac{\mathrm{N}}{y}} = \mathrm{R} \text{ or } y = \sqrt{\frac{\mathrm{R}\,\mathrm{N}}{r}}.$$

The first formula is corrected in Clark and Sabine's tables. It is strange that these are the only two text-books, that I know of, that contain a practical formula for arranging cells for maximum current. The subject is mentioned incompletely in Munro and Jamieson, p. 355.

Will you kindly give me a description of the newest form of non-polarised No. 2 side relay for the quadruplex, used in the postal telegraphs. The quadruplex is extensively used in Australia, the direct circuit between Melbourne and Sydney being 570 miles.

H. W. Jenvey, *Electrician.*

Chief Telegraph Office, Melbourne,
Victoria, Australia, *May 28th*, 1887.

Practical Electrical Measurement.

There was an absurd clerical error which escaped my notice when correcting the proofs of the article criticised by Profs. Ayrton & Perry. I wrote, "Profs. Ayrton . . . showed that to make the power error least, voltmeters should be wound with German silver. The writer dissents entirely from this view." I ought to have written "copper," not "German silver." Profs. Ayrton & Perry advocated the use of copper, I hold that voltmeters should be wound with German silver. I then go on to show why voltmeters should be wound with German silver and not with copper.

The temperature error in a voltmeter is due to variations in temperature of the room, and to variations due to heating from the power spent in the instrument. In considering the last we must distinguish between the case in which the voltmeter is left permanently in circuit, thus rising to a fixed temperature, and the case in which the voltmeter has a key, and is only in circuit for a short time while a reading is being taken.

Taking Profs. Ayrton and Perry's figures ("Proc. Phys. Soc.," Vol. VI., p. 65), German silver has 13 times the specific resistance of copper, and the rate of increase of resistance of copper is only 8·8 times that of German silver. If the wire were uninsulated, or if the thickness of insulation were proportional to the diameter, and if the rise of temperature were proportional to the power spent, it is obvious that German silver should be used in all parts of the coil. But the thickness of insulation is constant; and thus a fine wire has what is virtually a higher specific resistance than a thick one.

Suppose a pair of similar voltmeter coils are made, and one is wound with German silver wire of radius y, the radius inclusive of insulation being $y + b$, then if the other is wound with copper to have the same ampère turns and same electromotive force, it will take less power. Let the copper be chosen to give the same ampère turns as the German silver, the diameter of the bare wire is then $\frac{y}{\sqrt{13}}$ if German silver has 13 times the specific resistance of copper. If the insulation of the copper bore the same relation to its diameter as in the German silver coil the resistance of the copper coil would be 13 times as great, and the power taken would be $\frac{1}{13}$th; but as the insulation thickness is constant and therefore greater in proportion in the copper coil, the wire is too short to be 13 times the resistance. If the insulation were proportional the radius of the copper wire would be $\frac{y+b}{\sqrt{13}}$, but instead of that it is $\frac{y}{\sqrt{13}} + b$, so that if R is the resistance of the German silver coil, that of the copper is

$$13\,\mathrm{R}\,\frac{\left(\frac{y+b}{\sqrt{13}}\right)^2}{\left(\frac{y}{\sqrt{13}}+b\right)^2}$$

The power spent in the copper coil is thus more than $\frac{1}{13}$th of that spent in the German silver coil. If the resistance of the copper coil is reduced to 8·8 times that of the German silver coil their temperature errors will be equal. Taking the thickness of insulation as 4 mils. or ·004 inch altogether, so that $b = 2$ mils, and solving the equation

$$13\,\mathrm{R}\,\frac{\left(\frac{y+b}{\sqrt{13}}\right)^2}{\left(\frac{y}{\sqrt{13}}+b\right)^2} = 8{\cdot}8\,\mathrm{R},$$

we find that a voltmeter coil wound with No. 18 B.W.G. German silver has the same error as one wound with No. 28 B.W.G. copper. German silver should, therefore, never be used in sizes over 18 B.W.G., nor copper under 28 B.W.G. Of course voltmeters are not wound with these large wires, and should therefore be wound with German silver, even if it has the large temperature error here supposed.

Moreover, if the coil is left on long the rise of temperature is greater in the case of the copper coil, for, though the copper is a better conductor of heat, there is more insulation, and it is the insulation that keeps the heat in.

If the voltmeter has a key and is in circuit for a short time only, the rise of temperature is not as the watts, but rises faster in the case of the copper; for the specific heats of copper and German silver cannot differ widely, and the weight of the copper is less, as so much room is filled with insulation.

I have here dealt with a whole coil, but the same reasoning applies to any element or volume of a coil, except that instead of ampère turns ampère centimetres must be considered. The field produced, or the effect, is always a function of the ampère centimetres, so the reasoning holds whether the coil is wound with wire of varying diameter or not.

As to external resistances in series with copper active coils, I do not see what Profs. Ayrton and Perry complain of. The thing is obvious, and is the common property of all instrument makers. I, for one, knew of it in 1882, and any one who has thought at all about instruments must have seen it at once.

I was not aware Profs. Ayrton and Perry used three sizes of wire on their voltmeters, and I am glad of the information. I did not put forward this idea as new, for it is perfectly well known that the inner coils should be of fine wire, and the right increase has been calculated for some cases. In the case of a soft iron core sucked into a solenoid, the pull is not a question of the total ampère turns on the coil, and the pull due to any ampère turn can hardly vary inversely as its radius; in fact, I believe it is impossible to calculate the best diameters of the wires, and that the best thing to do is to follow Profs. Ayrton and Perry's example, and resort to experiment.

As to the motor meters, I had Profs. Ayrton and Perry's specification when I wrote the article, and mentioned that the arrangements used by Siemens is included in it. The motor meter was brought out previously by Edison, but as a coulombmeter. The point I wished to emphasise was that Profs. Ayrton and Perry used the copper disc which needs a torque nearly strictly proportional to the speed—a very important matter. The disc also compensates for temperature errors in the coils in a joulemeter.

I urged that the field should be wound with the thick wire, not to make the meter a joulemeter, but to avoid the loss of electromotive force due to the insertion of resistance in the main circuit. Profs. Ayrton and Perry merely say that of the armature and field one should be in the main circuit and one in shunt to it. The question whether a meter is a coulombmeter or a joulemeter is of comparatively little importance; what is wanted is a meter that will work.

As to the Ayrton and Perry clock meter, I believe I have been wrong in saying there is any contact breaker, as it cannot be necessary. As explained, I have not seen the instrument.

Jas. Swinburne.

The Electric Lighting Bill.

My attention has been called to two notices in your issue dated July 8th, with reference to my resolution anent electric lighting. Perhaps you will allow me space to state that my resolution has been duly placed upon the orders of the day; and to explain that there are two ways of moving a resolution; first, by a member reading the same out from his place in the House; or secondly, by handing in the same at the table, the course I pursued, and which has this advantage, that there is no fear of inaccuracy as far as the press is concerned, as the resolution, being printed in the orders of the day, is extracted therefrom into the daily papers. I took the precaution besides of sending a copy of the resolution to all the papers. Of course some of these did not insert it, but others, both in London and throughout the country, were good enough to do so. You may rest assured that I shall lose no opportunity of moving this resolution, and shall do so in the plainest and least ambiguous terms possible.

Perhaps you will allow me further to state that Lord Thurlow entirely sympathises with my resolution. If the truth were told, it would be found that the Board of Trade temporised with a view ultimately of rendering it impossible that even the emasculated Bill introduced by the noble lord should be passed this session. Splenetic influences evidently prevailed, and inasmuch as the noble lord who presides over the Board of Trade was thrown overboard by a more influential member of the present Government in the House of Lords, Lord Stanley has his revenge and the whole Bill has been thrown overboard. The session is drawing to a close, but those engaged in the industry may rest assured that even if my application to the First Lord of the Treasury for an opportunity to move my resolution during this session has no effect, I shall place it on the paper the first thing next session, and do what I can to further the interests of the industry, not animated by personal, but I trust national interests, so as to benefit all concerned.

No one sympathises more than I do with the almost life and death struggle which English pioneers have had in relation to electric lighting, and no one condemns more strongly the action of the Government in introducing a Bill which has had so suicidal an effect upon this new industry. I do not quite agree with you that the repeal of the Act, and a short Act enabling companies to take up streets would not have the effect of largely developing the electric lighting industry; in fact, I may say during the last few months, corporations and syndicates have been moving actively with a view to the establishment of large installations for the supply of public and private lighting, and in every case these have had to be abandoned, as upon enquiry at the Board of Trade, it was found that it was absolutely impracticable to attempt anything in the manner and on the scale proposed. The public desire electric light, and are prepared to pay a little more for it, but the recent marvellous discoveries and developments in the new science have placed electric lighting, when carried out on a large scale, on a favourable basis as compared with gas. Such, at least, is the experience of the company of which I am chairman, and I have no doubt whatever that it equally applies to other energetic pioneers and companies.

I will endeavour to obtain you a House of Commons order of the day containing my resolution, and send you the same, and will also acquaint you with any further steps I take in the matter, so that your journal may, should it think fit, give the desirable publication of the same.

Hugh Watt.

July 11th, 1887.

[Mr. Watt is in error in supposing that we are opposed to his motion for the repeal of the Act. What we suggested last week was that something besides favourable legislation is necessary to make extended electric lighting practicable and remunerative. Where that something is already possessed, we are in complete accord with Mr. Watt when he says that an Act of the kind he desires would largely develop the electric lighting industry.—EDS. ELEC. REV.]

Threepenny Telegrams.

I was pleased to see in your Editorial Notes, in reply to my suggestion of the above, that although you seemed to infer that I may have to live a very long time in order to see "threepenny telegrams" come into vogue, yet you fully agree with me that they would be "such desirable conveniences."

I am not unacquainted with the inner working of a telegragh office, having myself worked in and had charge of one some years ago; and I am not likely, therefore, to suppose, as you suggest, that either the great speed of the present automatic instruments, or the increased carrying capacity of the wires are the only elements to be considered in coming to my conclusion that threepenny telegrams will come into vogue before very many years have passed over our heads; and that the cost of the transmission of each *can be* and will be very greatly reduced.

I take it for granted that nearly all the commercial world and a great many others would not only most warmly welcome the reduction, so that their postal correspondence might be reduced, and their business more rapidly transacted day by day and hour by hour, but that such a reduction would much more than quadruple the general use made of the telegraph.

Taking the country throughout there are at present hundreds, and probably thousands of miles of wires which are only partially occupied with the transmission of news or messages. There are hundreds of telegraph offices and instruments only partially so occupied; and there are hundreds of telegraph clerks in the same condition.

Very little extra expense would be incurred by the department if these were all fully, or more fully occupied.

On busy and fully-occupied lines the increased speed at which news, stocks, and newspaper work generally, can be transmitted by the automatic instruments, leaves the wires at liberty a much longer time every day for the manual transmission of messages.

Then, has the department already reached all the possibilities of duplex, quadruplex, and Delany's working?

Probably, too, messages may be delivered direct from the instruments without transcription, by the use of some new and rapid form of type printer; and the extension of the use of the pneumatic tubes for the transmission and delivery of news and messages would greatly assist the object in view.

Increased help in the lower grades of the department would, of course, be needed, and useful employment would be given to many more.

There are many other ways in which the proportionate cost of the transmission of messages might and would be decreased, but for the present I have probably indicated sufficient to support my assertion and belief that the introduction of "threepenny telegrams" need only be dependent upon the time required by the Post Office department to prepare for it; and that the immensely increased use that would be made of the telegraph for all purposes would soon put it on a sound basis financially.

E. Cox-Walker.

Darlington, *July 12th*, 1887.